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RESEARCH INSTITUTE, NEW DELHI

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# THE HAWAIIAN PLANTERS' RECORD

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## Some Notes on Irrigation at the Waipio Substation

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By J. A. VERRET and F. C. DENISON

These notes cover some studies made on water measurements, the object being to get some data on the amounts of water used per day and the acre inches applied per acre by individual irrigators.

The measurements were made at the watercourse by means of V notch weirs. Such measurements are accurate to possibly within 5 per cent. In some cases the error may be greater than this. The portable weirs were placed in the head of each watercourse on a level ditch. We endeavored to eliminate all velocity of approach and to have a good still pond, but, especially in big canes, this was very difficult. Measurements of the head passing over the weirs were made every half hour, and the time required to complete the watercourse by the irrigator was carefully noted.

The flow being used by the irrigator when the weir was put in was kept as constant as possible during the test, that is, the irrigator was not allowed to speed up while being checked.

### SUPPLY AND LEVEL DITCH LOSSES

In obtaining these data we measured the water with a Great Western meter as it entered the supply ditch and checked this amount against the quantities shown in the watercourse. The average distance from intake to average watercourse was approximately 2,000 feet. The work was in cane 16 months old and 28 days since previous irrigation. The irrigators were using 159,670 gallons of water per day as measured at the supply ditch meter. Water was being applied at the rate of 6.35 acre inches per acre measured at the watercourse, or 7.8 inches when measured at supply ditch meter. In this case the loss between supply ditch

intake and the watercourse was found to be 19 per cent. The following is a summary:

Total water measured at supply ditch ....	1,890 ac. ft. = 615,858 gallons
Total water measured at watercourses.....	1,527 ac. ft. = 497,574 gallons
<hr/>	
Loss.....	.363 ac. ft. = 118,284 gallons
Per cent loss	= 19 per cent.

#### WATER APPLIED PER ACRE AND PER MAN DAY

Our measurements were made in seven different fields with cane varying from seven to sixteen months of age.

Field	Age of Cane	Crop	Days Since Previous Irrigation	Acre Inches Per Acre At Source	Gallons Per Man Day At Source	Acres Per Man Day At W. C.	Acres Per Man Day
J and K	16	Fourth ratoons	28	7.38	147,120	119,160	0.69
J	16	Fourth ratoons	28	8.74	248,480	201,270	0.87
F	15	First ratoons	13	6.82	175,800	142,390	0.95
S	7	Fourth ratoons	16	6.82	181,350	146,890	0.98
T	7	Fourth ratoons	16	6.95	162,600	131,710	0.86
U	7	Third ratoons	16	7.41	179,000	145,010	0.89
V	7	Third ratoons	15	7.41	179,000	130,340	0.80
<hr/>				<hr/>	<hr/>	<hr/>	<hr/>
Average				7.36	181,900	145,250	0.86

From the above we see that the acre inches applied per acre when measured at supply meter varied from 8.74 inches to 6.82 inches with an average of 7.36; when measured at the watercourse these figures become 7.08 inches maximum, 5.52 inches minimum and 6.01 inches average. The gallons of water per man day measured at the supply meter varied from 147,000 to 248,000, averaging 181,900 gallons.

The area irrigated per man day was 0.86 acre. We feel that this is somewhat low. Irrigation at Waipio is on the day basis, as we have not found it practical to give long term contracts. We are now working on a plan to have the irrigation done by the short, individual contract system.

#### AGE OF CANE AND AMOUNT OF WATER APPLIED PER ACRE

As the cane becomes older, trash accumulates in the bottom of the lines and cane stalks tend to obstruct the lines and watercourses, slowing up the water and causing more seepage. This increases the amount of water used per irrigation.

The figures at Waipio were as follows:

16 months cane = 8.06 acre inches per irrigation;

7 months cane = 7.15 acre inches per irrigation.

In other measurements not reported here, we applied about 3 acre inches in plant cane 3 months old.

#### INCREASING THE HEAD, LESSENED AMOUNT OF WATER APPLIED PER ACRE

In making this test the same irrigator was used. The head of water given him was varied with the watercourse. The irrigation was done by irrigator No. 79, one of our best men. The results show as follows:

Watercourse	Gallons Water Per Man Day	Acre Per Man Day	Acre Inches Per Acre at Watercourse	Gallons Per Acre
8	149,200	.954	5.76	156,400
10	155,300	1.222	4.68	127,100

By speeding up the work in this case we were able to reduce the acre inches applied from 5.76 to 4.68 inches per acre. This represents a saving of 29,300 gallons of water per acre, or 12½ per cent. At \$20.00 a million gallons this amounts to 59 cents per acre per irrigation. In conducting this test every effort was made to keep all conditions the same except the change of head of the water. The same irrigator as before noted, worked in watercourses near to each other on the same level ditch. The two line "come-back" system was used in irrigating, and the water was stopped as soon as it reached the end of the second line. With this in mind we feel safe in stating that difference in water used per acre, 29,300 gallons, represents extra seepage. This is a direct loss for Waipio conditions, as a three-inch irrigation is about all the water Waipio soils will hold to a depth of six feet under normal moisture conditions. These results point to the importance of using as large a head of water as the condition of the soil will allow. But one must bear in mind that merely increasing the head is not all that is necessary. All the good of the increased head may be lost if the irrigation is allowed to fill the line too much. We are inclined to believe that there is nothing to gain, and much to lose under most conditions, in allowing the water to run into an ordinary length line longer than it takes to run from one end to the other.

We are of the belief that in the majority of cases irrigating and weeding by the same man leads to a waste of water and is a great deal more expensive than we realize. Separate weeding would lead to economy of water.

#### VARIATIONS AMONG INDIVIDUAL IRRIGATORS .

We found a rather wide variation in the areas covered and the amounts of water used by different irrigators and by the same irrigators from day to day. The average work of the different irrigators in the various fields irrigated during this test is summarized:

Irrigator Bango 22	Acre Inches* Per Acre	Acres Per Man Day	Gallons Per Man Day
3	5.46	0.92	136,400
79	5.58	0.92	139,400
64	5.66	0.91	139,860
61	5.68	0.85	131,100
7	5.72	0.97	150,660
34	6.43	0.84	146,600
13	6.48	0.86	151,330
17	6.48	0.87	153,100
98	6.81	0.79	146,100
83	6.90	0.66	123,660
53	7.03	0.77	147,000
24	7.10	0.90	173,510
Average		.86	

The first six men in the above list did better than the others. Illustrating, let us take irrigators Nos. 22 and 24. They irrigated approximately the same area per day, but No. 24 used 44,500 gallons more water per day. At \$20.00 per million this amounts to 89 cents a day. For Waipio conditions we feel certain that any irrigation of more than  $5\frac{1}{2}$  inches is of no benefit. No. 24 is not irrigating any more.

## The Philippine Mole-Cricket Wasp (*Larra Luzonensis*) in Hawaii

By FRANCIS X. WILLIAMS

The mole cricket is almost wholly a subterranean insect. Its small, protuberant beady eyes seem to suggest that it is a creature of the darkness. Unlike the ordinary field cricket with its more exposed manner of living and depending in great measure upon agility for safety, it has little use for leaping powers within the narrow confines of its burrow and has developed instead remarkably large and strong hands and a long cylindrical body that serve its purpose admirably.

At certain times the mole cricket will migrate on top of the ground, or the long-winged form takes flight and is frequently attracted to light. It is a very extensive burrower, usually quitting its more secure and deeper day-tunnel during the night to make the well-known superficial burrows that appear as low cracked ridges along the surface of the ground. Of long life and more or less omnivorous in habit this insect is often guilty of serious depredations on crops, the "Changa" or West Indian mole cricket (*Scapteriscus vicinus*) being particularly notorious in this respect. On the island of Oahu, Hawaiian Islands, the immigrant mole cricket *Gryllotalpa africana* occasionally does considerable injury in cane fields

\* Water measured at watercourse.

by eating the eyes, shoots, roots, and even the ends of the "seeds" themselves; in addition, it burrows into irrigation ditches thereby causing leakage. (See Swezey, *Planters' Record*, XXVII, pp. 38 and 39, 1923.)

Mole crickets, of which there are several genera and numerous species, generally frequent moist places and are very expert surface swimmers. With such profound and secretive habits, one would not expect them to have many insect parasites, which indeed seems to be the case, a single genus of wasps, *Larra*, appearing to figure alone in this role. Nowhere are these wasps represented by many kinds, and of the ten or more species studied from a standpoint of life history, each wasp seems addicted to a particular species of mole cricket. Thus the Brazilian *Larra americana* preys upon *Scapteriscus didactylus*, the Australian *Larra femorata* and *Larra sclesta* upon *Gryllotalpa coarctata* and *Gryllotalpa nitidula* respectively, while in the Philippines, the large, forest-loving *Larra carbonaria* attacks *Gryllotalpa hirsuta* of similar habitat, with a new species of *Larra*, and *Larra luzonensis* having the widespread *Gryllotalpa africana* as their host. These wasps explore the mole cricket tunnels, often penetrating very moist soil, drive the occupant to the surface and there do battle with it, nimbly springing upon its back and administering stings in the soft underside of the thorax and head; in this way the cricket, which may be young or full-grown, is paralyzed for a length of time sufficient for the wasp to glue her egg firmly under the thorax. Soon the victim revives and hastily burrows in the ground to lead an active life until it succumbs to the developing wasp grub, which often consumes it in its entirety and spins a hard oval cocoon. The total life cycle for these insects in the tropics seems usually between 6 and 9 weeks duration.

While at Los Baños in July, 1917, the writer made a few observations on the life history of *Larra luzonensis* and succeeded in rearing a specimen from egg to maturity, the cycle occupying forty-two days. On his second trip to the Philippines, more *Larra luzonensis* were secured and a very small shipment of it sent to Honolulu in August, 1921. But 4 wasps, apparently all females, issued from the lot and were liberated in Manoa Valley, on September 19. In December of the same year another small lot of *Larra luzonensis*, and a slightly larger one of a rarer *Larra* with a red abdomen that also preys on the mole cricket we have in the Hawaiian Islands, was sent to Honolulu. From this lot resulted, again, 4 females of *Larra luzonensis* and from the 13 cocoons of the red kind, 9 females and 2 males issued, of which 8 females were liberated in Manoa Valley. No wasps became established from these two shipments.

In July, 1924, I succeeded in bringing from Para, Brazil, a lot of about 55 cocoons of two species of *Larra*, *Larra americana* and a smaller species, both having a black and red body, that preyed upon two species of *Scapteriscus*. Upwards of two dozen wasps issued, mainly in Honolulu, a few perishing during the voyage thereto. *Larra americana* prevailed in numbers. As their prey differed from *Gryllotalpa* not much hope was entertained of these wasps becoming established on Oahu; they did, after considerable coaxing, parasitize our mole cricket, but only a few mated females could be obtained, and of these 3 mated pairs of *Larra americana* and 4 mated females and 1 male of the second species

were liberated in a wet sugar cane field infested with mole crickets, on Kahuku plantation. No success appears to have attended these liberations.

*Larra luzonensis*, except in certain localities, seems quite rare in the Philippines, but C. E. Pemberton, associate entomologist of this Station, who went to the Philippines in 1925, hit upon the happy expedient of spraying corn plants at Los Baños with a saturated sugar solution and thereby attracted the desired insect in sufficient quantity to breed enough for three large shipments to Honolulu. These were received June 10, June 24, and July 8, 1925. From these lots, totalling 577 parasitized mole crickets, 184 wasps are known to have been produced; in addition 79 cocoons were buried on two sugar plantations. The insect was liberated as follows:

Ewa Plantation Company—Field 5, mauka end. Seventy-two adults, from June 20 to July 20.

Waialua Agricultural Company—Field Mill 9. Forty-nine cocoons buried June 26; 44 adults, July 13.

Kahuku Plantation Company—Field 2B, 30 cocoons buried July 10.

Manoa Substation—68 adults from July 7 to July 29.

This *Larra* has found conditions to its liking in these Islands, for it has become very thoroughly established. On September 3, 1926, we found it numerous, for this type of insect, on Waialua Agricultural Company, occurring in Mill Fields 6 and 9, and at 2D Kawaihapai; on September 7, it was recovered from Field 5, Ewa Plantation Company; it has not yet been seen at Kahuku; in Honolulu the first specimen was captured on a screened window of one of the beach hotels on October 2; on October 25, a parasitized mole cricket was taken at about 1,700 feet on the peak of Tantalus and subsequently wasps were abundant there; November 9, fifteen or twenty specimens were found at Ewa in Field 5, and one specimen was taken in Field 13B, there. Males may be seen in abundance feeding on certain honey-dewed bushes at the head of Manoa Valley.

This useful wasp resembles somewhat the Philippine field-cricket wasp, an insect about the same size but generally grey-black in color, lacking the red of the middle legs and possessed of greater activity. *Larra luzonensis* may be recognized by its polished black abdomen, the red on the middle pair of legs and by the manner in which it hunts its prey: it explores mole-cricket-burrows, now and then disappearing in one of them, and the often punctured condition of these burrows indicates the abundance of the wasp. It is to be looked for on the plantations along the moist, more exposed open ditch banks. Already it is far more numerous here than at Los Baños, whence it comes. Thanks to a scarcity of natural enemies here, it should be expected to greatly lessen the numbers of mole crickets in our fields. Being so active a wasp, it must soon reach the island of Kauai, the only other island of the archipelago where its natural prey is known to occur.

## A South American Ground Beetle as a Wireworm Enemy

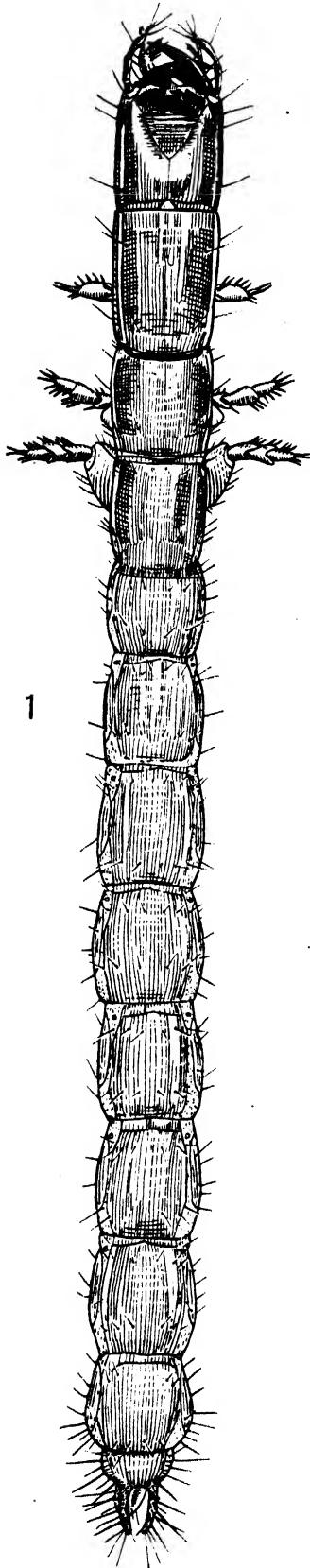
By FRANCIS X. WILLIAMS

The ground beetles or Carabidae constitute one of the largest and most important families of the Order Coleoptera, and as their common name implies, occur on or near the ground, remaining in concealment during the day and coming out at night to prey upon weaker insects and other invertebrates. Many of the commoner forms are black in color and are protected from their enemies by their swiftness of movement, secretive habits, or by a malodorous quality.

There are numerous exceptions to the general habits among these insects, particularly in tropical regions, for we know of many "ground" beetles that live in trees, a fact particularly true of the Carabidae of the Hawaiian Islands. And in the New England states, the large, brilliantly metallic *Calosoma sycophanta*, an introduction from Europe, may be very conspicuous as it scales the trunks of forest trees in broad daylight in search of its large and succulent prey, the caterpillar of the Gypsy moth. Other and native species of *Calosoma* are often seen hurrying over the ground in the daytime.

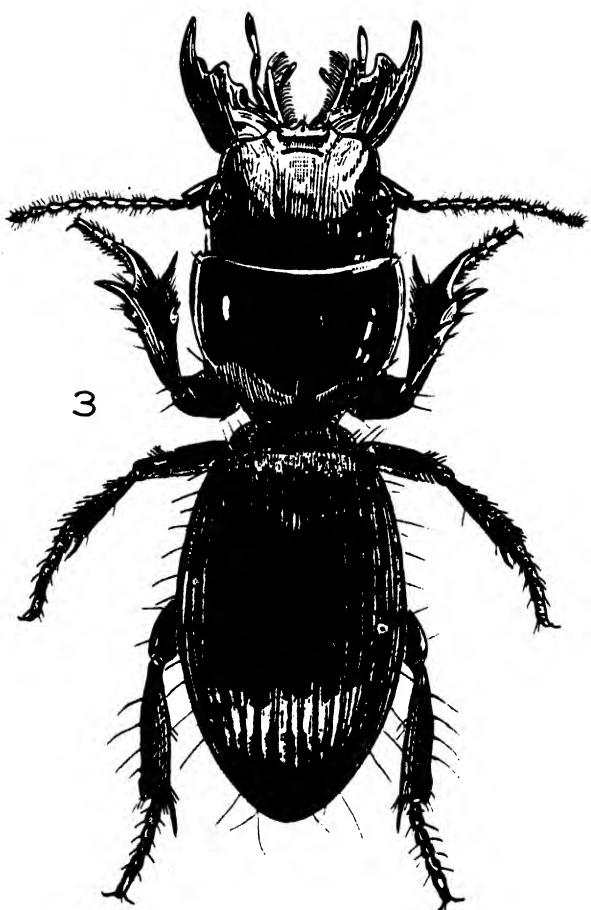
The great majority of Carabidae are mainly predaceous and play an important part in suppressing injurious insects, destroying them particularly in the larval stages; certain ground beetles, however, enjoy a mixed diet, feeding both upon plant and animal substances and thus such genera as *Harpalus*, *Anisodactylus* and *Amara*, may be quite injurious as seed eaters.

The ground beetle figured in this article is one of the Scaritini, a tribe whose members are particularly terrestrial and whose early stages are passed underground. It was rather abundant in the city of Belem, Para, Brazil, where both larvae and adults were dug out of the sandy soil. No eggs were found. Presumably these are laid underground, hatching out as slender active larvae that much resemble wireworms, though generally more elongate and possessed of a truculent disposition. When full-grown (Fig. 1) the larva is about an inch long with the head and thorax of darker color and harder than the rest of the body, which is pale yellow with the tail end forked. The legs are strongly developed for rapid progress through the soil, being much thickened and provided with stiff spines. At this stage it is of considerably greater length though far slenderer than either pupa or adult. The pupa particularly, is very short inasmuch as the head is bent down upon the breast (Fig. 2), while in the adult (Fig. 3) it is extended as usual. The pupa is somewhat less than half an inch long and has the back provided with some erect hairs that probably serve to keep it off the moist soil as it lies in its pupal chamber. The beetle, which measures about  $\frac{2}{3}$  inch long, is at first soft and pale but its integument soon hardens and the color becomes a polished black. It is quite incapable of flight, having no wings under the fused elytra or wing cases. The tibia of the forelegs is strongly broadened and armed with heavy spines and forms an excellent digging apparatus. Its well developed mandibles



1

2



3

indicate a predaceous habit. The majority of specimens were found at the bottom of rather deep and nicely cylindrical burrows.

By dint of much digging during May and June of 1924, in a garden in Belem, a small lot of larvae and adult *Searitini* were secured, nearly all of which survived (without food) the four weeks' trip from Brazil to Hawaii, where they—14 adults and 11 larvae—as well as a single specimen of a larger species, were liberated on the Honokaa Sugar Company plantation. They have probably not become established, in view of the small size of the shipment, the comparative paucity of animal food available in the soil, and the rather long developmental stages of the beetle. The adults in some cases readily seized hold of larvae or pupae of *Monocrepidius* wireworms that were offered them, and the grubs are fully able to overcome softer insects, as white grubs.

## Pre-Harvest Sampling for Cane Ripening\*

By W. P. ALEXANDER

*Head of Department of Agricultural Control and Research, Ewa Plantation Company*

Which field shall be harvested next?

This is a question which has to be answered by the management of a plantation many times during the season. If every field could be harvested when it was ripe, the production on all plantations would be greatly increased. This is asking the impossible, for, due to mill capacity and labor supply, the grinding season lasts from six to eight months. Also, fields to be planted and to be short ratoons are harvested early. There must be a compromise, and the management that is able to schedule the harvest of the fields with some definite knowledge of the *stage of maturity* will be in a position to increase sugar yields. Appearance of the cane field is often deceptive as regards its ripeness.

One then naturally asks: Is it not possible to cut samples in a field of cane before harvest and from an analysis of the juice determine its ripeness? It would be the logical thing to do, and, offhand, seems a very simple method of securing the desired information. I have been unable to find out just how many plantations attempt to obtain such samples regularly throughout the grinding season and the technic involved. I hope discussion at this meeting will bring out this point. The Ewa Plantation Company inaugurated a program of *systematic* pre-harvest juice sampling in September, 1924, and a year later the Oahu Sugar Company started using the Waipio test mill for a similar purpose. Both plantations had previously taken samples on special occasions but there had not been a definite plan for the entire crop. I append a letter from H. W. Robbins, chemist at Oahu Sugar Company, analyzing his results for the 1926 crop. His methods of sam-

\* Presented at the fifth annual meeting of Association of Hawaiian Sugar Technologists October, 1926.

pling are essentially the same as those used at Ewa and the cane is also ground in a "Cuba A" mill manufactured by the Squire Manufacturing Company. Data therefore should be comparative.



Cuba "A" mill used to grind pre-harvest juice samples

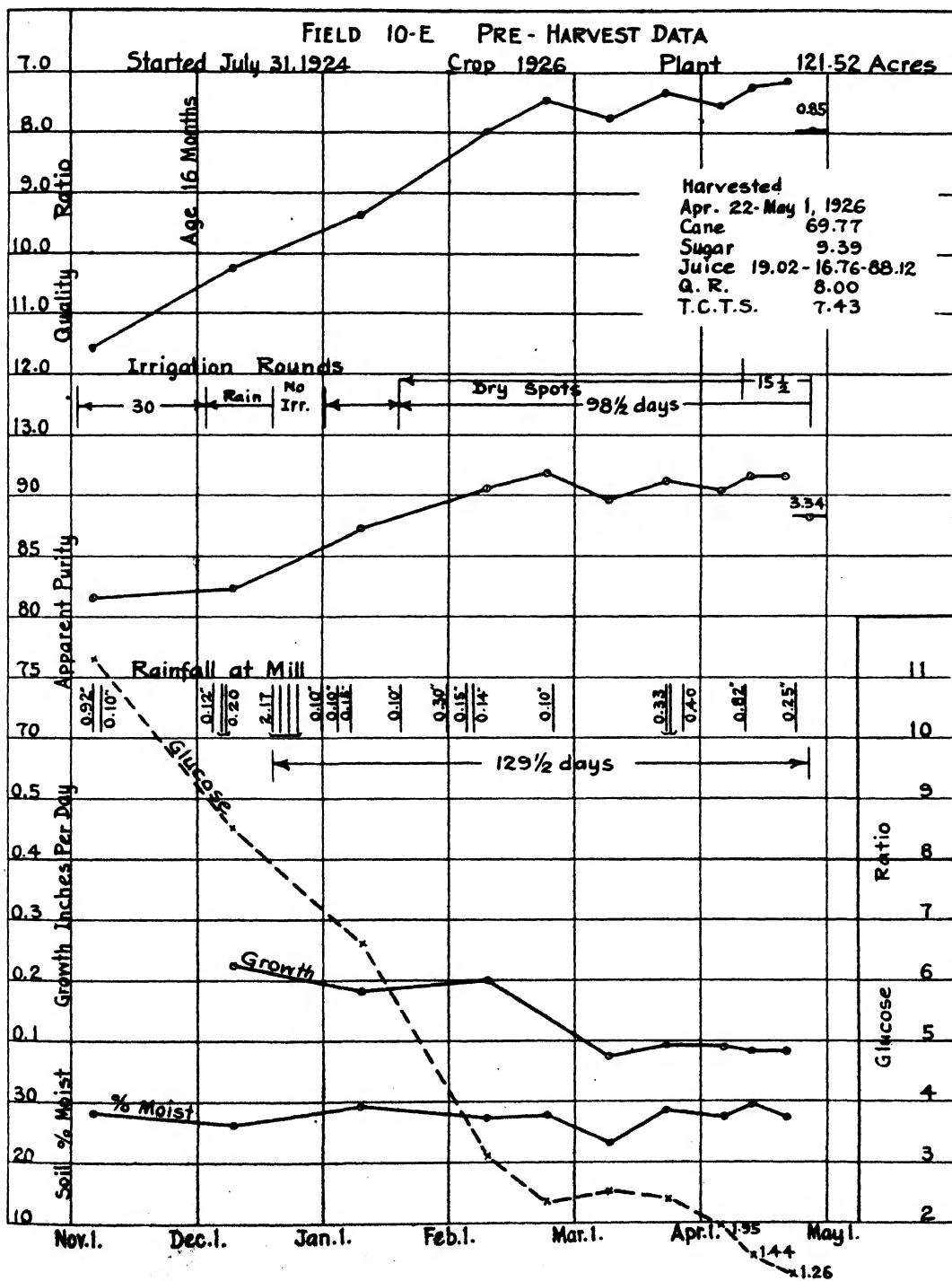
The following brief remarks will treat of the procedure followed at Ewa Plantation Company and the conclusions that can be drawn to date:

Three methods of sampling have been tried, namely: (1) Carload lots from edge of field crushed at mill; (2) Five stalk samples ground in test mill (see photo); (3) Java system—five stalk samples divided into three equal portions of top, middle, and bottom and the juice from each section analyzed separately.

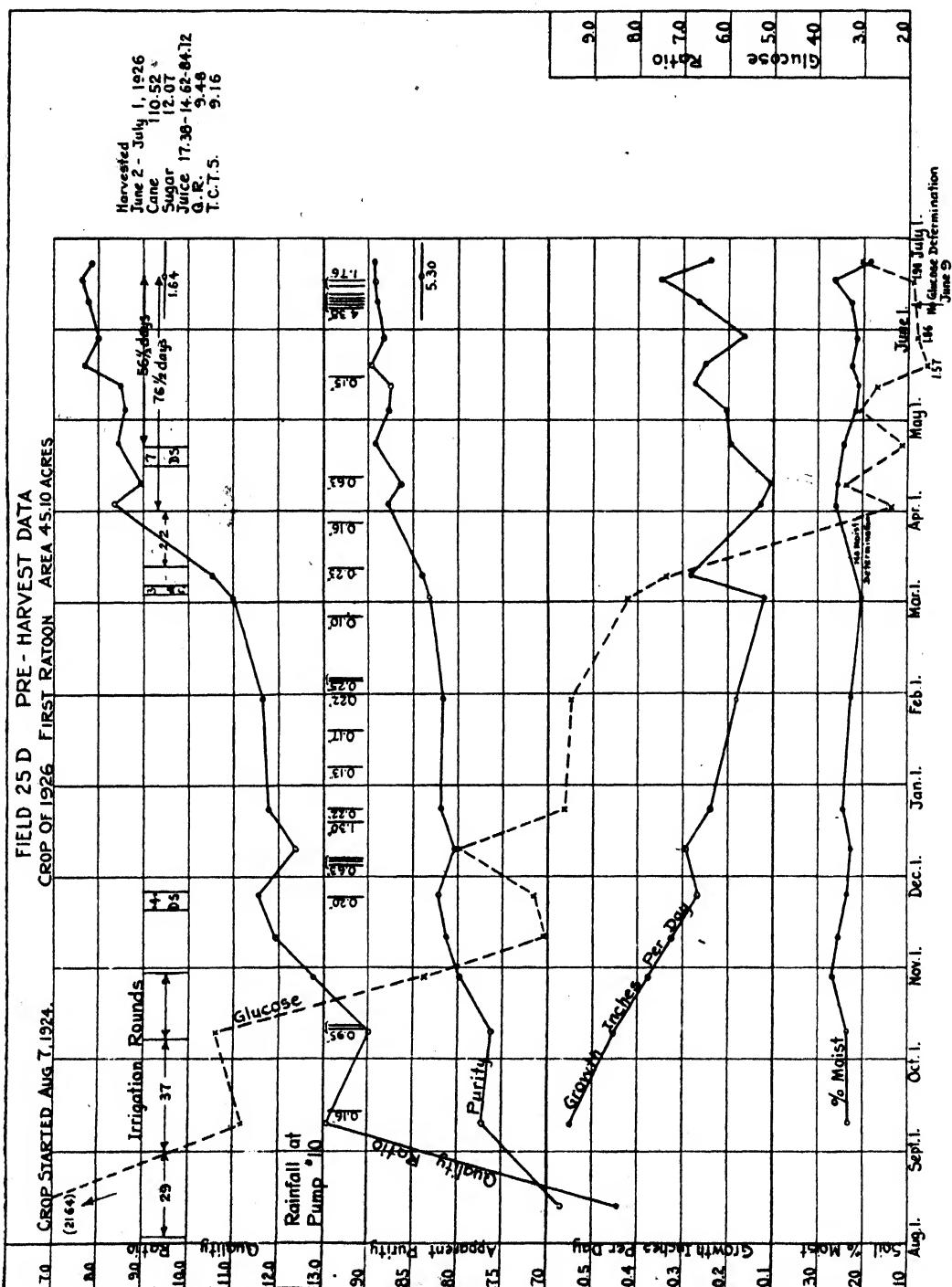
The first gave very erroneous results, as the cane invariably seemed to have better juice on the outside of the field. The third gave very interesting information, but was of no more practical value than the second, which will be described in detail. Areas are selected in a field which appears to represent average conditions. One site is chosen for every 20 acres or more, depending on soil variation. It is situated at least 100 feet from the edge of the field and at least 50 feet from the nearest ditch and also 10 feet from a watercourse. Five stalks are cut from a stool or stools in consecutive order along the same cane line. They are topped at the base of the fifth leaf. Care must be taken not to break and lose the stalks which may be as long as 15 to 20 feet entangled among other stalks in a veritable jungle. At the same time a boring is made to a 2-foot depth and a soil sample is obtained from which a moisture determination is secured. Growth measurements are made on five adjacent stalks of cane. The above operation, including packing out the sample and moving to a new location, consumes on an average 40 minutes. Two men usually work together, and they must be conscientious and reliable if the work is done properly. Samples start 8 to 6 months previous to harvesting and are taken at periods of from 1 to 4 weeks, the interval decreasing as harvesting approaches.

The cane is weighed\* and ground in a motor-driven "Cuba A" mill having polarization extraction of 60 to 65 per cent. Analysis of juice shows Brix, polarization, purity, quality ratio, glucose, and glucose-polarization ratio.

Records are kept on a visible card index and also graphed as shown in Graphs 1 and 2.



\* Also measured at Oahu Sugar Company.



We are trying to sample a non-uniform material—a field of maturing cane. Just how great this variation within a single field is from a group of 5 stalks to another group of 5 stalks was emphasized when a series of 60 samples was taken in sets of ten. The first ten samples had an average quality ratio of 7.49 while the individual five stalk samples taken consecutively at the same time gave quality

ratios of 7.30, 8.20, 7.33, 7.16, 7.11, 7.42, 6.50, 7.32, 9.80 and 7.26. (It would be my guess that the next to the last sample contained a sucker.)

The second averaged 7.12 quality ratio and individually showed: 7.37, 7.11, 7.13, 7.18, 7.18, 7.80, 6.74, 7.06, 6.82 and 6.93.

The third averaged 7.84 quality ratio and individually showed: 8.17, 7.78, 7.18, 8.13, 7.73, 7.68, 7.18, 7.83, 8.52 and 8.40.

The fourth averaged 7.94 quality ratio and individually showed: 7.76, 7.66, 7.17, 7.45, 8.64, 7.07, 8.17, 7.94, 8.63 and 9.52.

The fifth averaged 7.07 quality ratio and individually showed: 6.59, 6.86, 6.94, 7.58, 7.87, 7.16, 7.47, 7.08, 6.76 and 6.65.

The sixth averaged 7.25 quality ratio and individually showed: 6.56, 6.65, 8.11, 7.03, 7.14, 6.84, 7.12, 7.58, 7.51 and 8.38.

A study of the actual samples of crusher juice from individual fields of the 1926 crop shows that the quality ratio had a mean deviation of  $\pm 0.47$ . In other words, while the average quality ratio might be 8.0 we could expect daily samples to range from 7.5 to 8.5. With these fluctuations within a field of cane, due to the many uncontrollable factors of environment and growth, one cannot expect five stalks of cane chosen from 20 acres of a field to pre-determine the exact status of the entire portion of the field. Theoretically, the greater the number of samples one takes the closer one will approximate the true condition of any given field, but a limit is reached due to the added cost of such intensive sampling. If one could find a sample location or locations approximating field average, the data would be satisfactory. Selections of such average sites must be based upon past experience. A trial is being given this method of sampling.

With such great divergency of sucrose content within the field it would be anticipated that the pre-harvest juice samples would not be comparable to the crusher juice. The average differences between the crusher juice of the field and the juice samples from the test mill, just previous to harvest, are given with the mean deviation from the average:

	Average Difference	Mean Deviation
Brix .....	+0.4	$\pm 0.7$
Polarization .....	+1.1	$\pm 0.9$
Purity .....	+4.0	$\pm 1.5$
Quality Ratio .....	+0.8	$\pm 0.5$

Some of this increase for the test mill, of course, is accounted for by having clean, unburnt cane milled immediately after cutting. The difference, however, is not consistent enough so that a correction factor can be applied. To illustrate, a typical comparison is shown:

	Typical Field Crusher Sample	Average Range of Pre Harvest Samples		
		Minimum	Average	Maximum
Brix .....	18.5	18.2	18.9	19.6
Polarization .....	16.0	16.2	17.1	18.0
Purity .....	86.5	89.0	90.5	92.0
Quality Ratio.....	8.5	8.2	7.7	7.2

These, therefore, seem to be the average limits within which pre-harvest juice samples can be made for one particular local condition.

The work done in sampling cane for ripeness during the 1925 and 1926 crops at Ewa should be considered experimental, and was used for two purposes, viz: (1) Actually furnishing the management with data as to fields which had the highest sucrose content and those which were in the various stages of maturity, and (2) in studying the cane ripening process from a theoretical standpoint.

The present status of the project may be stated as follows: It is doubtful if a few samples can be secured that will be a representative index of the field as a whole or even portions. However, it is possible to obtain from the samples the general trend of the ripening process over a period of months. These typical changes in the formation of sucrose are shown in Graphs 1 and 2 and are of practical value in bringing the cane to its highest peak of sucrose.

By a liberal interpretation of such charts, one was able to better direct the project of sucrose improvement, i. e.:

(1) One was able to follow the ripening process previous to suspension of irrigation and better control the amount of water.

(2) One had a better basis upon which to decide from a small group of fields scheduled for a certain month, which particular one was mature.

(3) One knew in what stage of ripeness the fields were at any particular time. Whenever a field showed a tendency to go back, one usually was able to detect the lowering of purity before the damage had become acute and remedy the situation by harvesting the cane.

(4) In general the preliminary sampling of the fields furnished information that indicated the best way of ripening a field and when to harvest to secure the highest sucrose content.

Mr. Robbin's letter, giving his results of analysis for the 1926 crop, follows:

The tables enclosed show the results of our field sampling during the past crop.

In Table 1 a comparison is given between the average of the crusher juice from thirty-one fields and the last field sample taken from the same fields previous to harvesting.

The ratio between the small Waipio mill and our crusher juice had previously been determined by the H. S. P. A. on the scale of harvesting at Waipio. The ratio resulting from the averages of the thirty-one fields shown, is somewhat higher and may be due to evaporation in the cane harvested. While the sucrose extracted by the crusher approximates that extracted by the Waipio mill the glucose is much higher. The Waipio mill juice represents cane uniformly topped and ground immediately after cutting while the crusher juice represents all the cane, including the suckers, and was subject to the unavoidable delay in grinding, when harvesting over a large area.

In connection with this work we have been trying to find a method for using the ratio of the polarization to the glucose, in crusher juice, as a guide to the ripeness of the cane. It was thought that a high per cent of solids not sugars, would give a low purity to a juice from cane that might be ripe. To start with, we assumed that when the polarization was 35.5 times the glucose the cane was ripe. That ratio was then taken as a standard of ripeness equal to 100. This figure per cent standard of ripeness fluctuates widely with small changes in the polarization and glucose, but does not indicate when the cane is at the ripest stage.

In Table 2 the fields are given in the order of their purities. There was not a great deal of variation in the non-sugars, and consequently the standard of ripeness followed the purity in general. The three fields planted to D 1135 were all high in non-sugars. Two of those fields, 4B and 57D, were harvested at the beginning of the crop and were low in purity and per cent standard ripeness. The other field, 43, was harvested during the

middle of the crop and stood seventh in the scale of ripeness and twenty-eighth in purity, due to low glucose and high non-sugars.

The following letter was received on December 31, 1926 (two months after presentation of the above paper), and gives in more detail the work of the Oahu Sugar Company:

Cane ripening studies were started on the Oahu Sugar Company, in September, 1925.

At this time, the immediate object in view was to try out systematic pre-harvest juice sampling as against carload lots from the edges of fields. The first year of this work was devoted to furnishing the management with data showing the relative ripeness of fields from time to time. We were also studying the cane ripening processes in their relationship to cultural practices and irrigation.

The ultimate end in view of this work is to control the ripening of our fields, as far as possible, through the regulation of our cultural practices, chief of which is irrigation, in an endeavor to reach a maximum ripeness of the fields. In addition, the harvesting schedule may be rearranged within certain limits from time to time depending upon the maturity and ripeness of the fields.

The general procedure for pre-harvest sampling is briefly as follows:

A plot is selected in each 20-25 acres of cane so located that the average of all plots will be representative of the field as a whole. Each plot is located between 75 to 100 feet from the edges of the field or from ditches. One stalk is cut from each of five lines in the plot no less than six feet from the watercourse. The stalks are cut flush with the bottom of the furrow and topped at the base of the eighth leaf. The next set of samples is taken, at a later date, just beyond the last sample.

The stalks are carefully dragged out of the field and are measured and bundled by plots. Then they are taken to the mill, weighed by plots and crushed; the juice from each plot is analyzed separately. The cane is ground in a "Cuba A" mill. The following data are recorded:

Date	No. of Stalks		Length of Stalks		Weight of Stalks		Weight per Foot of Cane	
	Total	Average	Quality		Total	Average	Pol.	
Brix	Pol.	Purity	Ratio	Glucose	Glucose	Glucose	Remarks	

Correction factors are used to translate the "Cuba A" mill analyses in terms of the commercial mill.

Samples at monthly intervals are taken from four to six months prior to harvesting a field; the interval is decreased as harvesting approaches.

In addition to the above method, the Java system was tried for a while, but was abandoned for the reason that it did not give results commensurate with the tremendous amount of detail work. It gave us, however, very interesting data.

Carload samples from the edges of fields were not satisfactory in that they were not a true representation of the field and showed the relative ripeness of only a small part of the field.

Correct field sampling is an important problem in the study of cane ripening. There is a tremendous amount of variation between stalks in a field of cane because of stalks in various stages of maturity, rotten stalks, rat-eaten and borer-eaten stalks, tasseled stalks, etc. The question is what kind of stalks shall we take? What per cent of the whole does each kind of stalk represent? The problem of field sampling for studies of cane ripening processes would be solved if we knew the correct answer to these questions.

Variation in samples means variation in results so that the data must be interpreted liberally. We must also make allowances for a certain number of discrepancies entering into the work as well as the human element.

To sum up the work, it might be said that up to date, pre-harvest samples have furnished data to show the trend of field ripening from which we have been able to change the harvesting schedule to a certain extent with advantage. This applies to groups of fields only. The layout of a plantation as influenced by contour and also the method of harvesting have quite a distinct bearing on the subject.

The studies of cane ripening processes are being continued and amplified.

TABLE I  
Comparison Between Waipio Mill Juice and Crusher Juice for Thirty-one Fields—Crop of 1926

	Brix	Pol.	Purity	Glucose	Sugars	Not Sugars	Pol. Glucose	Per Cent Standard Ripeness	Pol. or Glucose Purity	—Solids Per 100 Brix—	Non-Sugars
Crusher Juice .....	19.21	16.89	87.93	.80	1.52	21.1	59.5	87.93	4.16	7.91	
Waipio Juice .....	19.04	17.38	91.28	.49	1.17	35.5	100.0	91.28	2.57	-6.14	
<b>Crusher</b>											
Waipio H. S. P. A.* .....	98.0	92.5	....	....	....	....	....	....	....	....	
<b>Crusher</b>											
Waipio O. S. Co. <sup>†</sup> .....	100.89	97.18	....	163.3	....	....	....	....	....	....	
Crusher Juice by H. S. P. A. Ratio	18.66	16.08	86.2	....	....	....	....	....	....	....	

\* The H. S. P. A. ratio between the Waipio juice and crusher juice was established by taking samples from cars of loaded cane that was ground soon after sampling.

† The Oahu Sugar Company ratio is a comparison of samples from the fields ground in Waipio mill, with the average crusher juice of the harvested fields.

TABLE 2

## Cane Ripening Data—Crop of 1926

Field	% Standard Ripeness	Brix	Crusher Juice			Cane	Tons Per T. 96°
			Polar. or Purity	Solids %	Brix		
45-A	77.1	20.01	90.2	3.3	6.5	15.70	6.71
45-B	81.5	19.63	89.9	3.1	7.0	15.43	6.83
46-B	76.1	18.93	89.9	3.3	6.8	14.66	7.11
39	60.5	18.76	89.3	4.2	6.5	14.68	7.12
22	75.2	19.43	89.3	3.4	7.3	15.16	7.04
23	82.1	19.98	89.0	3.1	7.9	15.34	6.84
48	67.2	20.10	89.0	3.7	7.3	15.35	6.96
24	82.0	20.30	88.9	3.1	8.0	15.66	6.81
36	71.9	20.70	88.8	3.5	7.7	15.71	6.74
37-A	80.0	21.41	88.8	3.1	8.1	16.42	6.51
35-A	65.7	20.01	88.7	3.8	7.5	15.42	6.91
15	68.6	19.24	88.6	3.6	7.8	14.82	7.08
44	61.3	19.65	88.6	4.1	7.3	15.12	7.07
16	65.1	19.82	88.6	3.8	7.6	15.13	7.06
18	67.8	20.11	88.5	3.7	7.8	15.26	7.01
37-B*	57.2	18.01	88.5	4.3	7.2	13.71	7.74
4-A	72.8	20.19	88.4	3.4	8.2	15.09	7.06
47	53.1	18.58	88.2	4.7	7.1	14.18	7.43
13	63.4	20.90	88.2	3.9	7.9	15.73	6.83
27-A	69.3	20.10	88.1	3.6	8.3	15.28	7.04
21	54.9	19.49	88.0	4.5	7.5	14.81	7.25
46-A	49.6	19.44	87.9	5.0	7.1	14.80	7.30
25	57.3	18.98	87.9	4.3	7.8	14.27	7.46
49	48.2	17.93	87.8	5.1	7.1	13.61	7.77
50	44.7	17.28	87.3	5.5	7.2	13.02	8.10
57-B	47.0	18.15	87.3	5.2	7.5	13.65	7.85
12	59.3	19.77	87.3	4.2	8.5	14.79	7.22
43	72.7	19.28	87.2	3.4	9.4	14.67	7.38
17-A	45.27	19.01	87.1	5.4	7.5	12.14	7.45
9-B	53.6	19.91	87.0	4.6	8.4	14.72	7.34
27-B	57.8	19.57	87.0	4.2	8.8	14.61	7.43
14 E & F	50.4	17.93	86.8	4.8	8.4	13.46	7.97
5	61.7	19.43	86.8	4.0	9.2	14.71	7.39
4-C	56.4	20.15	86.3	4.3	9.4	14.82	7.38
35-B	43.7	17.78	85.6	5.5	8.9	13.16	8.25
14-D	40.0	18.16	85.4	6.2	8.4	13.89	7.89
59	48.3	18.50	85.2	5.0	9.8	13.74	8.04
14-A	40.5	18.60	84.9	5.9	9.2	13.89	7.89
34-A	44.0	17.60	84.3	5.4	10.3	12.76	8.77
33	47.1	17.69	84.2	5.0	10.8	12.79	8.54
34-B	43.7	17.55	84.0	5.4	10.6	12.61	8.82
4-B	37.7	17.59	82.9	6.2	10.9	12.54	8.90
57-D	34.5	17.05	82.7	6.7	10.6	12.18	9.29

## Factory Test on Alkaline and Neutral Clarification

By W. L. McCLEERY

The following test was run at Ewa factory during the latter part of the 1926 grinding season. The object was to amplify our present data showing comparisons on a factory scale between "alkaline" and "neutral" clarification. By alkaline clarification is meant the method now in quite general use wherein the hot limed juice is held between 8.0 and 8.3 pH, at which point laboratory work at this Station has indicated the maximum increase of purity is obtained. Neutral clarification refers to the practice followed until a few years ago, in which the clarified juice and syrup were about neutral to litmus. It is recalled that the investigation of clarification was taken up as a major project by the sugar technology department of the Station in 1921. Early in 1922, Mr. Walker, then factory superintendent of the Pioneer Mill Company, began using the information by that time available, changing his method of operation to practically that now in general use. His first few weeks of experimental run showed an increased purity between mixed juice and syrup of somewhat over 1.2, or about double their usual figure. Since then alkaline clarification has, with the exception of a very few factories, become general throughout the Islands.

This experiment was arranged so that the higher liming was to be carried out during the day and the moderate liming at night. The day reaction of the cold limed juice was to be held between 8.6 and 8.8 pH, corresponding to approximately 8.3 pH on the juice leaving the heaters, and giving a clarified juice of about 7.5 pH with the syrup slightly lower. Factories grinding cane with low phosphoric acid content would need to lime to only 8.4 or 8.5 pH on cold juice to obtain these hot juice and clarified figures. The reaction at night was to be from 7.8 to 8.0 on cold juice with the clarified juice in the neighborhood of 7.0 pH.

The comparative data to be obtained besides pH determinations included difference in syrup purity, as well as difference in purity increase from mixed juice to syrup; also turbidity by the Kopke turbidimeter and syrup filtration rates by the Elliott apparatus and by the pressure filter of the Celite Products Company.

The test started July 29, 1926, and lasted nine days. The prescribed limits of liming were closely adhered to with the exception of one day and night during which time the above figures on cold juice were slightly exceeded. The pH determinations, purities and turbidity data are from laboratory records as determined in the regular routine. The Elliott filtrations were run by the writer and the pressure filtrations by Mr. Elsenbast, of the Celite Products Company. The averages given below are arithmetical including those of pH determinations.

The tabulations show that the cold juice average pH was 8.75 on the day and 8.06 at night, with the clarified juice 7.55 and 6.97 respectively. The drop in pH from cold limed juice to clarified was somewhat greater than found in some factories, but during this time the phosphoric acid in crusher juice was .043 to .059 per cent (.227 to .330 per cent Brix), all higher than the general

average, so that this drop can be considered normal. The pH drop from heated juice to clarified is not affected by the fluctuations of phosphoric acid present in raw juice. Therefore the pH of hot juice used as the basis of liming control is the means of obtaining the most even reaction on clarified juice and syrup.

The turbidity was markedly better on the day than on the night shift with the exception of the first day. The average was 3.83 against 3.08. The day figure was close to the expected for the above amount of phosphoric acid with the day shift pH values.

A higher syrup purity was obtained on each day shift than on the corresponding night shift, the average difference being 0.96. The purity increase from mixed juice to clarified averaged 0.88 higher on day than night. As there is a lag of close to three hours between the raw juice and syrup stages in the factory, it is likely that the purity and filtration rate differences given below represent only from 50 to 75 per cent of the actual. There was no allowance for this lag in time, because of the large amount of work being handled by the laboratory and for fear of confusion resulting in wrong compositing of the day and night samples.

The Elliott or vacuum filtration rate on syrup of 43.6 per cent for the day compared with 38.6 for the night, with pressure filtration rates of 112 and 97 respectively, show a difference in favor of the day with the Elliott test of 13 per cent and of 15 per cent for the pressure filter. It is noticed that at the end of the run the filtration rates were much lower than at the beginning, even though all factory conditions were kept as uniform as possible. Fluctuating rates over a wide range were found to be characteristic during the period of over seventy consecutive days this summer that these data were kept at this factory.

#### CONCLUSION

An improvement in purity between the two methods of liming of about 0.9

Date 1926	DAY					NIGHT					Differences
	Mixed Juice	Syrup	Inc'r	pH (Cold)	A. Purity	Syrup	Inc'r	pH	A. Purity	Purity	
7/29 . . . . .	8.63	82.4	85.02	2.62	8.25	82.3	84.93	2.63	.38	.38	-0.01
7/30 . . . . .	8.37	80.9	84.66	3.76	8.16	81.7	84.20	2.50	.21	.21	1.26
7/31 . . . . .	8.78	80.8	84.50	3.70	8.00	82.0	83.86	1.86	.78	.78	1.84
8/2 . . . . .	9.05	81.8	83.90	2.10	8.75	81.9	82.70	0.80	.30	.30	1.30
8/3 . . . . .	8.83	81.9	85.16	3.26	8.46	81.1	82.88	1.78	.37	.37	1.48
8/4 . . . . .	8.83	81.7	83.89	2.19	7.90	80.5	82.83	2.33	.93	.93	-0.14
8/5 . . . . .	8.78	80.7	84.28	3.58	7.88	80.7	83.31	2.61	.90	.90	0.97
8/6 . . . . .	8.70	82.6	85.49	2.89	7.30	82.7	84.20	1.50	1.40	1.40	1.39
8/7 . . . . .	8.77	81.4	84.28	2.88	7.86	80.6	83.71	3.11	.91	.91	-0.23
Average . . . . .	8.75	81.58	84.58	3.00	8.06	81.50	83.62	2.12	.69	.69	0.88

Date 1926	pH CLARIFIED		pH SYRUP		TURBIDITY CLARIFIED	
	Day	Night	Day	Night	Day	Night
7/29.....	7.48	6.94	7.3	7.0	3.37	3.83
7/30.....	7.56	7.14	7.2	6.6	4.04	3.74
7/31.....	7.58	7.17	...	7.0	3.53	3.22
8/2.....	7.50	...	7.3	...	3.80	...
8/3.....	7.34	7.20	6.9	7.1	3.92	3.32
8/4.....	7.30	6.76	6.8	6.9	4.00	2.62
8/5.....	7.88	6.63	7.4	6.6	4.35	2.35
8/6.....	7.44	6.90	...	7.1	3.46	2.58
8/7.....	7.86	7.00	7.6	7.0	4.00	2.94
Average.....	7.55	6.97	7.22	6.92	3.83	3.08

Date 1926	SYRUP FILT. RATE VACC. FILTER			F. R.	SYRUP FILT. RATE PRESSURE FILTER			F. R.
	Day	Night	Difference		Day	Night	Difference	
7/29.....	63.9	52.4	-11.5		200	142	-58	
7/30.....	46.3	58.2	+11.9		172	182	+10	
7/31.....	48.3	45.9	-2.4		130	116	-14	
8/2.....	...	...	...		...	...	...	
8/3.....	49.8	44.7	-5.1		100	102	+02	
8/4.....	35.9	31.1	-4.8		63	68	+05	
8/5.....	35.6	22.1	-13.5		72	28	-44	
8/6.....	33.6	26.0	-7.6		47	42	-05	
8/7.....	35.0	28.6	-6.4		...	...	...	
Average.....	43.6	38.6	-5.0		112	97	-15	
	+13%				+15%			

represents an increased recovery by S. J. M. formula of 0.7 per cent, or 7 tons more sugar per 1000 tons production. The lower liming with 6.97 average pH of clarified juice represents some inversion or destruction of sucrose as shown by research work recently published by this department. The greater clearness of clarified juice and better filtration rates found are also of some importance, as they result in cleaner and somewhat better filtering sugars at the refinery, and these items are obtained incidental to the larger increase of purity.

In general these results confirm on a factory scale the indications found in previous experimental work and give comparative figures between what is considered the optimum method of liming and the method formerly in use.

The writer is especially indebted to Messrs. Orth, Bond and Nolan, of Ewa Plantation, and Mr. Elsenbast, of the Celite Products Company, for cooperation in carrying out this test.

## Reports on Foreign Work in Entomology

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By C. E. PEMBERTON

MENADO, CELEBES, September 30, 1926.

I have spent most of September away from Menado searching for parasites of *Rhabdocnemis* other than the one species I have already mentioned. I visited some of the small islands lying between Celebes and the Philippines, extending northeast from Celebes about 200 miles. In a way these islands are greatly isolated, since they are separated from the Philippines, Celebes and each other by sea-depths ranging from 3000 to 6500 feet. As they lie in a more or less direct line in the distribution of *Rhabdocnemis* between Celebes, the Moluccas and the Philippines, I had some hopes of finding something interesting and of value. I examined palms on the islands of Togoelandang, Siao, Sangir and Taland (Salibaboo or Tulour) and some sugar cane on Taland, but found no *Rhabdocnemis* at all. On all of the islands sugar palms, sago palms and sugar cane are scarce, which perhaps accounts for the absence of the beetle. Some of the islands are almost completely covered with coconuts.

On Sangir Island, I was fortunate in having opportunity to see a striking example of what can happen on an isolated island when an introduced insect pest gets away from its parasites and other natural enemies. A scale insect, *Aspidiotus destructor*, was first noticed by the natives on a few coconut trees in a village at the north end of the Island 16 months ago. It has spread from this spot in a solid belt and killed outright about 500 acres of mature coconut trees and continues to advance. As the copra industry is a large one on this Island and the only one, this destruction, if unchecked, will literally drive the native population from comparative wealth to extreme poverty. As I was the first entomologist to see this, the only white man on the Island greeted me most effusively. In the affected belt every square inch of leaf surface is positively plastered with scales. These scales were unparasitized. In Java, Malay and probably other parts of the Archipelago this scale is well controlled by several parasites. I have informed my friend Mr. Leefmans, the Dutch Government entomologist at Buitenzorg, of this situation, and he is now preparing to introduce parasites to the Island. I think this is a most remarkable instance where the intelligent use of insect parasites can save an industry from complete ruin.

Upon returning to Menado I went into the elevated interior, living for a week at a place called Tondano. This is on a lake, about 10 or 15 miles long, at an elevation of 2250 feet. There are a good many sago swamps bordering this lake. In these I found an abundance of another species of *Rhabdocnemis*. During 5 or 6 days of work I succeeded in examining a thousand or more each of larvae, pupae, adults and cocoons and many eggs. Of this total only 3 were parasitized by the large *Ichneumon* which I mentioned in my last letter. The *Leptid* fly *Chrysopilus* was abundant. *Histerids*, *Hydrophilids* and *Anthocorids* were present but not common. The most effective check, as near as I could determine,

was the white fungous disease, which I have already sent from Menado. I found many dead larvae, pupae and especially adults covered with this fungus. This and the *Leptid* are the principal factors of control.

It is of interest that the two other small *Calandrid* beetles in this sago also suffered a heavy mortality from this fungus, yet I find no other of the many insects present in the sago attacked by it. The *Leptid* has proven itself adaptable to a wide variety of conditions, for I have now taken it in association with borers at sea level in sago swamps, in open fields in banana on banana borer, in the dark forests on *Rhabdocnemis* in sugar palms, in sago swamps at 2250 feet elevation as well as in sugar-palms there also, and in Java it was present with *Rhabdocnemis* in sugar palms at Lembang at 4000 feet elevation.

The *Rhabdocnemis* species which I found in sago at Tondano on the lake, does not seem to be present in the sago swamps at sea level near Menado, and I found more of it in sugar palms at Tondano and other elevated places which I visited. The common species of *Rhabdocnemis*, so like *obscura*, which I find here about Menado in sago and sugar palms, is also present in sago and sugar palms in the elevated districts.

I visited several places besides Tondano, namely: Rambokken, Kakas, Ratahan, Tomohon and Rurukan. Sugar palms are present in limited quantity everywhere, with the one species of *Rhabdocnemis* present, but I failed to discover any parasites or predators different from those about Menado, and nowhere did I find any favorable indication of the large *Ichneumon* pupal parasite, which is very disappointing.

Occasionally I find an adult *Rhabdocnemis* or larva dead with the green muscardine fungus *Metarrhizium*, but it would appear to be of no value at all as compared with the white fungus.

I am forwarding with this letter some specimens of this other species of *Rhabdocnemis* which I found in sago at Tondano. Included in the package is a specimen of a *Xylocopid* bee, something like the species in Hawaii, which bores in holes, posts, etc. I reared several hundred parasites from the larva of this bee, which I found in a dead limb in Menado. The dead larva and some of the parasites are also included in the package. As the *Xylocopa* is rather an economic pest in Hawaii, according to the Mutual Telephone people, I am sending this for what value it may have. Probably if efforts were ever made to introduce *Xylocopa* parasites to Hawaii, it should be started in the Philippines, from which region transportation is quite short to Honolulu, as compared with the Dutch East Indies.

At Mr. Muir's suggestion I examined some termites in Java for internal nematode parasites. The examinations were not extensive and I found none. Keeping it in mind, however, I have taken time to make some examinations about Menado. So far I have examined 3 genera: *Cryptotermes*, *Nasutitermes* (*Eutermes*) and *Termes*. I found nema in the abdominal cavity of immature nymphs of *Termes* taken from one colony, but none in the head, and also nema on the surface of the body of workers and nymphs in another colony of *Termes*. The nema were never abundant and only found after much dissection. Both *Termes* colonies appeared to be rather small, however. I have examined a large number

of *Nasutitermes* but have not seen a single nematode on or in any. I find no *Coptotermes*.

I am especially interested in an ant which lives within the *Termes* colonies directly with the termites. When first opening the covered earthen runways and seeing many of these ants I took them for strange modified forms of soldiers, but soon saw my mistake. These ants store large numbers of seemingly dead but preserved termites in parts of the nest reserved for themselves. These are probably stored for food.

In view of the presence of nema in certain termite colonies here, and of this interesting ant, and of still some hope for finding some other control factor on *Rhabdocnemis*, not yet unearthed, I do not feel justified in leaving Menado yet. I am quite a novice on ants and termites, but will devote a little time to it before leaving, especially the nema. I doubt if we want more ants in Hawaii.

Your letter of July 24 has just been received. The information you transmit with it respecting bird introductions to Hawaii, I find very interesting. I am very glad to have a copy of the resolutions passed by the Hawaiian Entomological Society on the subject.

I know nothing about the Peking nightingale, and unfortunately Menado is so far removed from the centers of scientific work in the Malay Archipelago and the Orient that there is no one here from whom I could obtain any first-hand information. If I, by chance, have any opportunity to learn anything about it, I will immediately forward the information. I suggest the name of Mr. McGregor, of the Philippine Bureau of Science, as a very reliable man to correspond with on the subject.

MAKASSAR, CELEBES, October 22, 1926.

I am today sending by registered mail a package containing living nematodes, reared from termites, collected at Menado, Celebes. This is addressed to Mr. Ehrhorn.

There are 8 tubes, each containing dead termites and from a few to several hundred living nematodes which have developed in the termites. In some of the tubes I have placed soil (sterile). In others there is nothing but the dead termites, the living nematodes and Tyroglyphid mites (living) which are often inseparably associated with the termites and cannot be avoided in the shipping of the nematodes. There are also a few Parasitid mites.

There will be many delays in the mails before this finally reaches Honolulu, and it is doubtful if any reach there alive, but it is well worth the trial. If the tubes do not dry out, many of the nema will probably still be alive.

Upon arrival I suggest that the contents of the vials be moistened, without removal, and living termites, especially *Coptotermes*, be inserted and left for 10 or 12 days, to permit development and multiplication of any nema that may be present.

I found that corking the vials to prevent drying-out soon resulted in the death of the nema. Cotton plugs are better.

I have placed clean paper in each tube to supply cellulose for the termites as long as they remained alive, but they are delicate insects and do not live more than 10 or 12 days when removed from their colonies and placed in small containers.

During about 3 weeks of study in Menado and vicinity I found nematodes in termites as follows:

<i>Cryptotermes</i> (1 species) .....	No nema
<i>Eutermes</i> (3 species) .....	No nema
<i>Termes</i> (small species) .....	..... Nema in abdominal cavity of small workers. Rarely in head.
<i>Termes</i> (large species) .....	No nema
<i>Neotermes</i> (1 species) .....	Nema in head of soldiers.
<i>Microcerotermes</i> (1 species) .....	..... Nema in head and abdominal cavity of workers.
<i>Coptotermes</i> (1 species) .....	..... Nema common in head of workers. Only one colony found.

During dissections of the small workers of *living termes*, I twice found a *Dipterous* larva distinctly occupying the abdominal cavity and filled with globules of the termite fat-bodies. However, of the many termites which I placed in tubes with soil subsequent to that, no flies have developed excepting Phorids, which occasionally get into the tubes and oviposit on the dead termites. I have found no more in the dissections. This was quite obviously a parasite and probably a Phorid.

The nema which occur in the abdominal cavity of the small workers of *Termes* and workers of *Microcerotermes* are distinctly not within the intestinal tract. By dissecting in water, the entire alimentary canal, excepting the oesophagus, could be easily removed intact. I found the nema lying free on the surface of the intestine and quite active. Usually only from 1 to 4 were present. They were very small (about  $\frac{1}{2}$  mm. in length). They evidently cause a premature death of the termite and complete their development in the decaying body of the host after it dies. By placing from 50 to 100 of these termites in a clean tube with a bit of clean paper for them to cling to, minute nema usually appeared on a few of those that died, soon grew to about  $1\frac{1}{2}$  mm. in length, mated and then very rapidly multiplied. Usually in 10 day's time all the termites would be dead and swarming with nematodes. The same happened with those species of termites in which the nema occur in the heads.

When clean termites were placed in tubes containing sterile soil, with paper, the same nema development occurred in the tubes in about 7 to 10 days' time. No nema development appeared in tubes containing species of *Eutermes*, *Cryptotermes* (1 sp.), and one large species of *Termes* and no nema were ever found in the dissections of these.

The small species of *Termes*, in which nema occurred in the small workers, did not always have nema in the colonies. Only one colony of *Coptotermes* was found and most of the workers taken from this colony had from 3 to about 8 nema per head. I cannot say that *Coptotermes* is rare in North Celebes, however, for I collected only for about 3 weeks.

The nema from these termites do not seem to be soil nema, for no development in the tubes containing termites, with soil, exceeded that in tubes containing termites but no soil. I am shipping some in soil only in the hope that in these the moisture will be retained better.

I have noted a quick mortality among all workers of *Termes* when placed in a large jar of soil in which I had succeeded in developing a large quantity of nema. This mortality occurred with two separate, inserted lots within 3 days. As the jar contained only soil, paper and thousands of nema, I could ascribe the early mortality only to the nema, which went on increasing until all of the termite substance was gone.

If any nema arrive alive in the shipment, I would suggest that they be allowed to increase in the tubes, by the insertion of *Coptotermes*, until abundant. Then fresh *Coptotermes* could be placed in for a day or two to allow infection and then replaced, living, in the colonies where they were collected.

I have not seen enough of the work of these nema to know of what value they are. I hardly think the Tyroglyphid mite is of any importance.

The ant which I mentioned in my last letter as a possible termite enemy does not seem to be definitely dependent on termites for food, though it is the only species I found about Menado that very commonly occurs intermingled with the termites in their colonies.

I found no further parasites of *Rhabdocnemis* in North Celebes and have not felt sufficiently encouraged in my findings there to remain longer.

I have only just arrived at Makassar and will investigate *Rhabdocnemis* in this region first before leaving for Borneo.

[Note. We have succeeded in rearing one generation of one of the nematodes on *Coptotermes*, but the difficulty is to find nests to experiment with as whenever found they are at once destroyed by fumigation. F. M.]

## The Length of Life of Seed-Piece Roots and The Progress of Sugar Cane Roots in the Soil at Different Ages of Growth

By H. ATHERTON LEE AND D. M. WELLER

### INTRODUCTION

During the course of growth-failure studies it has become apparent that to understand the degree of injury and nature of various factors affecting the roots, an understanding of the normal roots is first essential. Some progress is being made in developing knowledge of the normal roots and one step in such progress has resulted from the following experiments.

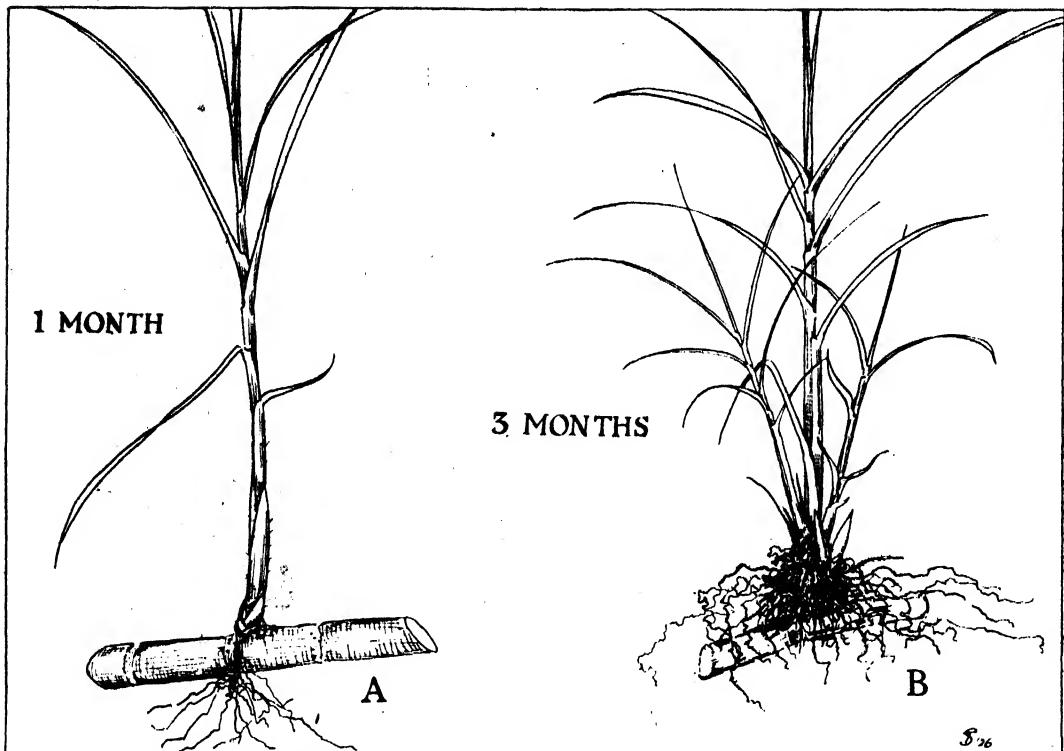


Fig. 1. A sketch attempting to illustrate the method of formation of roots in the early stages of the cane in the experiments. The bud of the cane cutting germinates to form a stalk and at the same time the root eyes of the cutting germinate to form roots. The stalk does not form its own roots until it has formed its first cane node and then produces roots from the root band at the node. Plant A, 1 month old, shows seed-piece roots formed almost exclusively, while plant B, 3 months old, shows stalk roots preponderating over seed-piece roots. The present experiments show that at the end of one month 97.3 per cent of the roots are formed from the seed pieces and only 2.7 per cent of the roots from the stalk. At the age of one month, therefore, the stalk is drawing nearly 100 per cent of its nutrients through the seed piece from the seed-piece roots. In the case of the 3 months old cane but 1.2 per cent of the roots consist of seed-piece roots and 98.8 per cent consist of roots given off from the root bands of the lowest nodes on the newly formed cane stalk. Thereafter the roots from the seed piece gradually decrease in weight until they are negligible and the seed piece decays.

As is perhaps commonly known, a seed piece of sugar cane, when it is first planted, puts out roots from the root bands at the same time that the eyes germinate. The eye grows into an aerial shoot, but it is some time before such a stalk forms its own roots, and during this period it draws its nutrients from the seed piece and through the seed piece from the seed-piece roots. By referring to Fig. 1, this can be more readily understood.

The experiments recorded here show the period in the life of normal cane, when these seed-piece roots function and the period at which the new cane plant puts out its own roots and functions for itself. The downward progress of the roots into the different levels in depth in the soil is also shown from these studies.

#### METHODS OF STUDY

Fifteen root-study boxes having the removable sides and horizontally placed wire netting as previously described (*Hawaiian Planters' Record*, Vol. XXX, No.

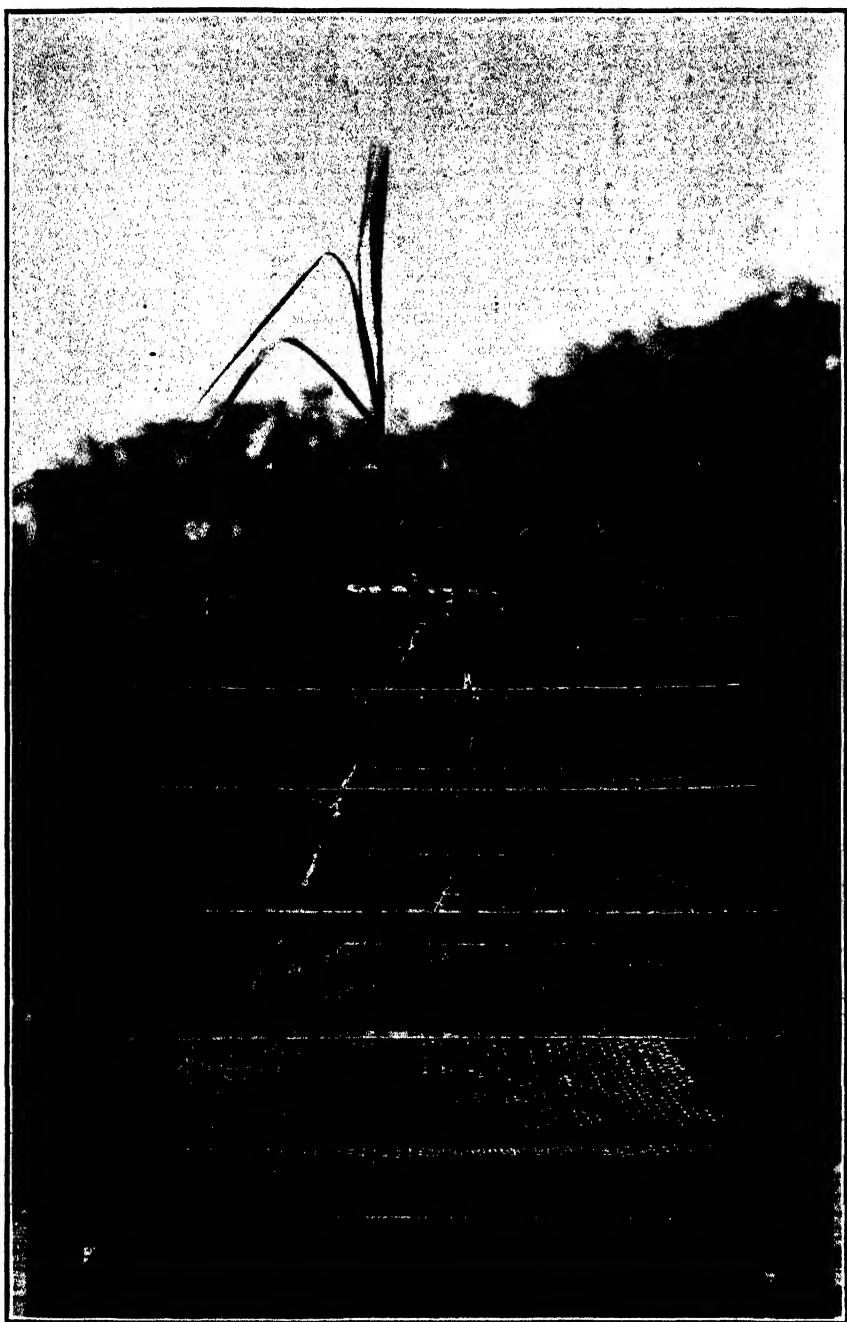


Fig. 2. Showing the character of the box in which the cane is grown. The sides of the box have been removed and the soil washed away, leaving the roots suspended in position on the wire netting. The cane at this age (one month from planting) averaged 97.3 per cent of its roots originating from the seed piece and 2.7 per cent originating from the aerial shoot or stalk.



2; April, 1926; page 267), were planted each with one seed piece of the variety H 109. These seed pieces were selected for uniformity in length of internodes, diameter and position on the stalk. They had previously been cut to three-eye seed pieces and gouged so as to leave only the middle eye. At time intervals of one month three of the boxes were selected in consecutive order according to their position, the sides removed and the soil washed away from the roots of the cane in each box. The roots of the cane were thus left in correct position suspended on the wire netting. The photograph reproduced in Fig. 2, shows the type of root-study box in use.

At different levels in depth in the soil, beginning at the bottom and working upwards, the roots were cut off; thus all the roots below the 24-inch level in depth were first cut off and collected. Next the roots between 16 and 24 inches in depth were cut at the 16-inch level, and collected; the roots between 8 and 16 inches in depth were next collected and then the roots between the soil surface and 8 inches in depth. In collecting these roots, those which emanated from the seed piece were carefully separated from the roots originating from the stalk. The separate root collections were then washed more carefully to remove all traces of soil, oven-dried and weighed.

#### THE RELATION OF SEED-PIECE ROOTS TO STALK ROOTS

Table I shows the weights of the seed-piece roots as compared to the weights of the stalk roots.

The results recorded in Table I show that the cane plant functions entirely by the use of the roots from the seed piece for one month; at the end of one month 97.3 per cent of the total roots originated from the seed pieces while only 2.7 per cent of the roots originated from the stalks of the aerial shoots. At the end of two months the situation had changed considerably, only 22.7 per cent of the roots having arisen from the seed piece compared with 77.3 per cent of the roots from the stalks of the aerial shoots. At the end of the third month the situation was completely reversed, with only 1.2 per cent of the roots emanating from the seed piece and 98.8 from the stalks of the aerial shoots. Thereafter the roots from the seed piece constituted but a negligible proportion of the total roots. The relation of the weights of seed-piece roots to the weights of stalk roots at different ages of growth is shown graphically in Fig. 3.

THE PERCENTAGES OF SEED-PIECE ROOTS  
AS COMPARED TO AERIAL-SHOOT OR STALK ROOTS  
AT DIFFERENT AGES IN THE CANE GROWTH

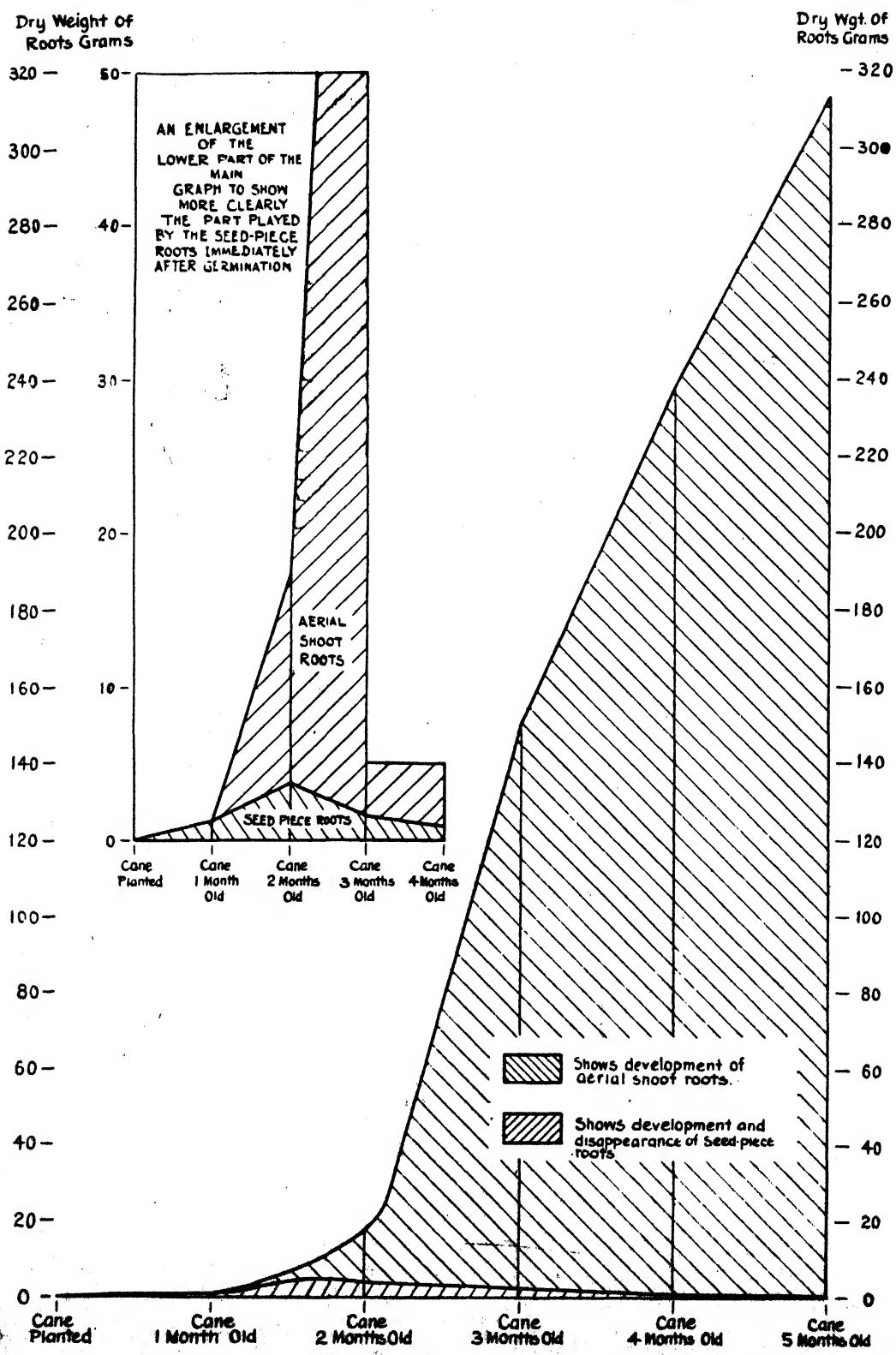


Fig. 3

*It is of interest that this change in the proportion of stalk roots to seed-piece roots was not due alone to the increased weight of the stalk roots; after the second month the seed-piece roots did not increase but actually decreased in weight.* At the end of the fifth month the seed-piece roots weighed but 6/10ths of a gram as compared to 333 grams of stalk roots, amounting to but 2/10ths of one per cent of the total roots.

*Therefore under normal conditions apparently the seed-piece roots alone furnish the nutrients for the stalk for the first month. After the first month and to the end of the second month there is a transition period during which the burden of supplying nutrients shifts from the seed-piece roots to the stalk roots. At the end of the third month and thereafter the burden of supplying nutrients rests almost entirely on the stalk roots since the seed-piece roots have disappeared.*

#### DISCUSSION

It has been argued from these data that fertilizers should not be applied to the cane until the stalk puts out its own roots, and that fertilizers applied to seed-piece roots, will only stimulate roots which will very shortly die and roots will be built up only to be wasted. More careful analysis would indicate there are reasons for early applications of fertilizers, which outweigh the foregoing. The stalk cannot form its own roots until it has formed at least one node and the accompanying root band at that node. Thus, fertilizers applied early will stimulate the formation of the first node on the stalk and hasten the formation of the first aerial-shoot roots. That part of the fertilizer which is not used by the seed-piece roots will remain for utilization by the stalk roots. That part of the fertilizer used in the formation of the seed-piece roots will not be lost, but on the decay of the seed-piece roots will be returned to the soil.

One would expect, therefore, that experiments with nitrogen and potash in the furrow, as well as phosphoric acid, would possibly result in interesting data.

In connection with root-rot studies there is an important conclusion to be drawn, namely, *that rots of the seed-piece roots after the first month of growth, should be distinguished from rots of the roots from the cane stalk; the decomposition of the former would seem to be more or less the natural life processes of the cane plant while, of course, rots in the stele of the roots of the cane stalk would be decidedly abnormal.*

#### THE PROGRESS OF THE ROOTS AT DIFFERENT AGES OF GROWTH

In addition to the data showing the comparative weights and proportions of seed-piece roots and stalk roots, data were obtained showing the development of roots of both classes in the different levels in depth in the soil at different ages of the cane. These data are recorded in Table II, showing the weights of the cleaned, oven-dried cane roots in the different levels in depth in the soil at the different periods in the age of the cane. The figures below show the combined weights of both seed-piece roots and the roots formed by the stalk; weights are in grams, and are the averages of three plants of each age.

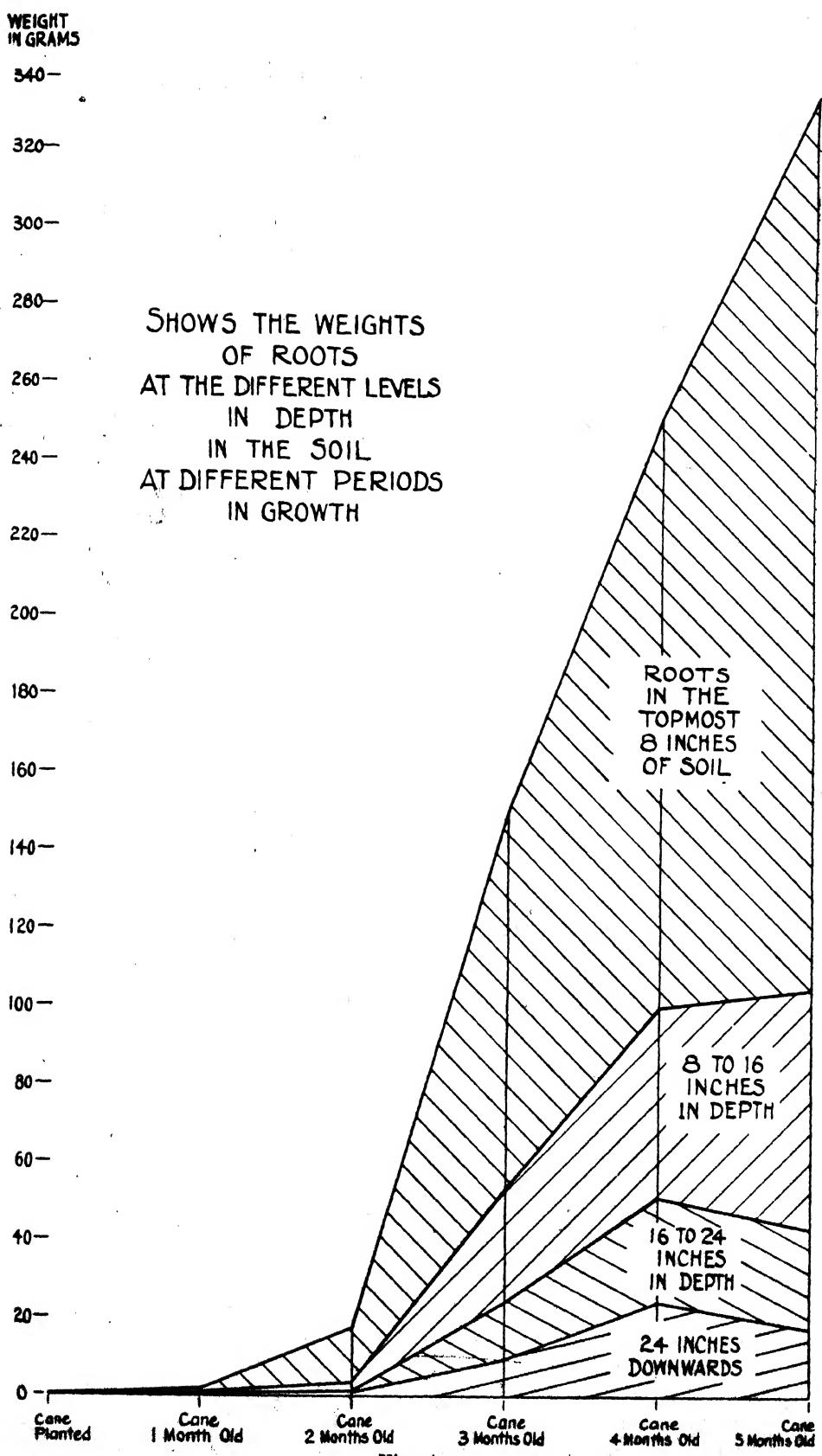


Fig. 4

TABLE II

## WEIGHTS OF ROOTS AT DIFFERENT LEVELS IN DEPTH IN THE SOIL AT DIFFERENT AGES OF THE CANE

Levels in Depth	1 Month Wgt.	1 Month Pet.	2 Months Wgt.	2 Months Pet.	3 Months Wgt.	3 Months Pet.	4 Months Wgt.	4 Months Pet.	5 Months Wgt.	5 Months Pet.
Topmost 8 inches . . .	1.130	85.6	13.20	75.5	98.52	65.0	151.2	60.3	229.6	68.8
8 to 16 inches . . . .	0.162	12.2	3.01	17.2	29.63	19.5	48.6	19.4	61.2	18.3
16 to 24 inches . . . .	0.025	1.9	0.94	5.3	14.11	9.3	27.0	10.7	25.4	7.6
24 inches downward . . . .	0.003	0.3	0.33	1.9	9.27	6.1	24.0	9.5	17.4	5.2
Totals . . . .	1.320	100.0	17.48	99.9	151.53	99.9	250.8	99.9	333.6	99.9

Examining the figures showing weights first, the results indicate what would naturally be expected, i. e., that the cane weights increased with age, and that the upper levels of the soil were first penetrated and the lower levels then penetrated successively. The weights of the roots in the different levels in depth at the different ages in growth are shown graphically in Fig. 4.

The figures concerning percentages of roots are fully as important as the figures for root weights, for in the application of fertilizers and irrigation water, one wishes to place such applications where the largest proportion of the roots exist, and total weights are not as relevant in such questions as are the percentages of roots. If one now refers to the percentages of roots in the different levels in depth in the soil as shown in Table II, it can be seen that starting with 85 per cent of the roots at the end of the first month *the proportions of the roots in the topmost 8 inches of soil gradually decreased until about 60 per cent of the roots were found in this level; the curve of the decrease then leveled off, and it is expected that the plants maintain somewhere between 55 and 70 per cent of their roots in this stratum until maturity*, at least the results of field root studies support such a view. At the same time *the percentages of the roots in the lower strata increased to a given proportion and the curve of increase then appeared to level off giving a more or less fixed proportion of the roots through to maturity*. The graph shown in Fig. 5 illustrates this approach to fixed proportions of root quantities in the different levels in depth in the soil, after the first few months of growth.

*It seems to us established from these studies, supported by field studies not yet reported, that water and nutrients to reach the greatest proportion of roots should be directed towards the uppermost 16 inches of soil where more than 75 per cent of the roots usually exist.* Our first impression, and that of many others when our data are first seen, that tillage before planting, also need only be shallow, seems to us not entirely warranted. With this work on roots we have come to the opinion that, given optimum moisture and nutrients, the outstanding factor for formation of the important secondary roots with their large proportion of

THE PERCENTAGES OF ROOTS OF PLANT H109  
 AT DIFFERENT LEVELS IN DEPTH IN THE SOIL  
 AT DIFFERENT AGES UP TO 5 MONTHS FROM  
 PLANTING

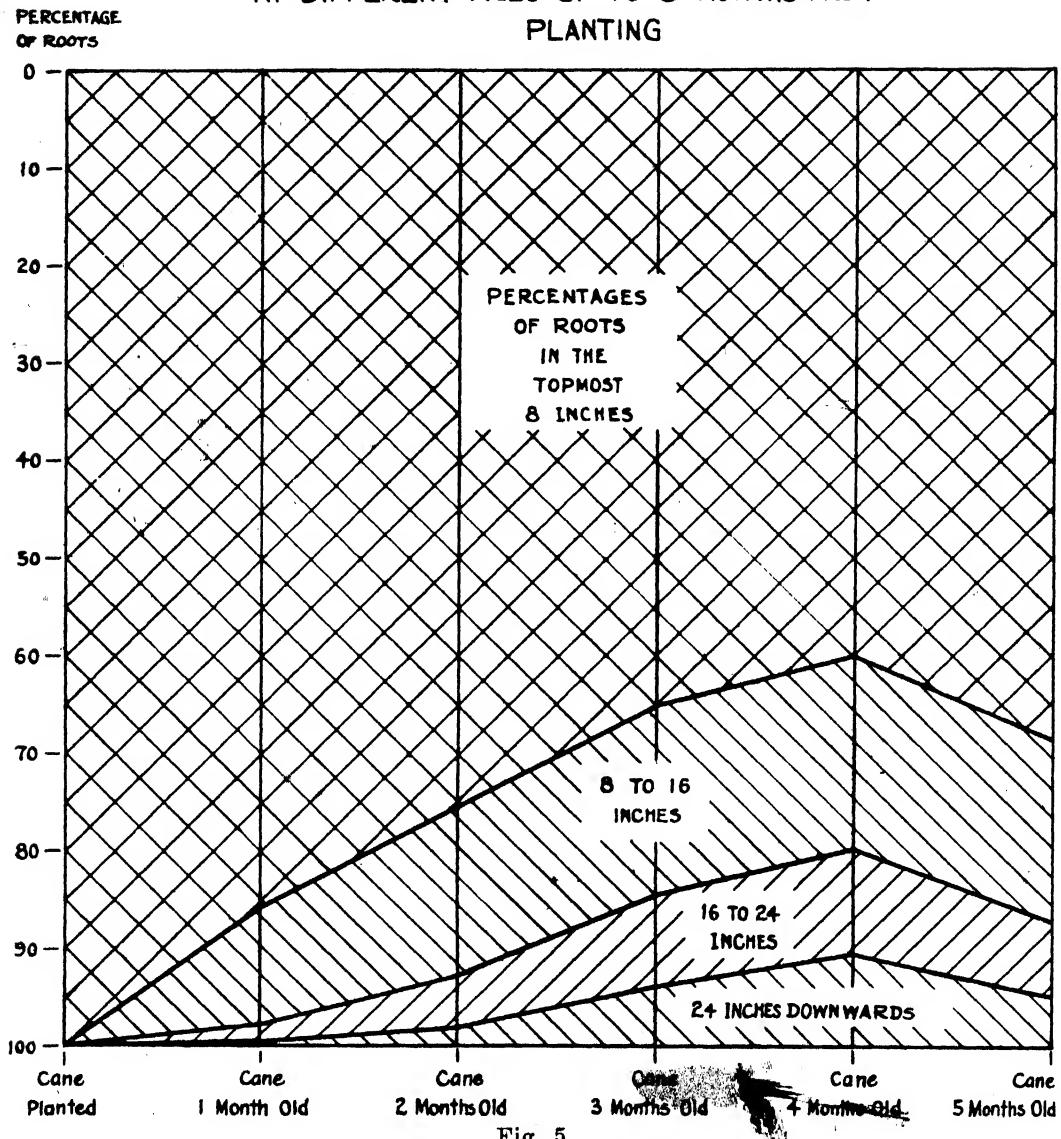


Fig. 5

feeding surfaces, is soil aeration. We do not have quantitative data to support this opinion; our views are based upon field observations only and we present these views as opinion only. If this opinion is correct then deep tillage and organic matter before planting would improve aeration and would improve and increase the feeding surfaces of the roots, and thus indirectly increase cane tonnage. The results are suggestive of field experiments to test root formation and cane tonnage with increased soil aeration as compared with control conditions.

Mr. H. P. Agee, also brings forward the suggestion that these data offer additional evidence in support of the modern idea that cultivation between the rows of growing crops has value chiefly in the function of weed control. Much

experimental work, locally with cane, and on the mainland with corn and other crops, shows that in the great majority of instances the damage to surface roots from such cultivation more than offsets whatever benefits may take place.

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## A Comparative Study of the Determination of Potash in Cane Juice by the Gravimetric and Sherrill Methods

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By L. E. DAVIS and G. R. STEWART

### INTRODUCTION

Ever since the early workers in soil fertility clearly demonstrated the need which plants have for mineral nutrients, there has been keen interest manifested in methods which could be used to determine the availability of these nutrients in the soil. The first work centered on the use of various weak solvents to dissolve out the more available soil materials. Water, both plain and carbonated, dilute citric acid, acetic, hydrochloric and nitric acids have all been employed. Dyer's (2) method employing one per cent citric acid has had very wide application, and our work in Hawaii has shown considerable value for the results obtained by this procedure.

A number of continental investigators have studied the possibility of determining the supply of available materials in the soil by the analyses of plant ashes. Hall (3) at Rothamsted carried on work along this line which led him to conclude that the significance of the figures obtained would vary with the crop. He did not find that the ash of cereals varied significantly, if grown on either good or poor soils. On the other hand, the potash content of the ash of mangel and swede, stock beets, gave a valuable indication of the needs of the soil for potash fertilization. Lately, Hoffer (4) working in Indiana has proposed that the fertilizer requirements of the corn plant can be found by making colorimetric tests on the tissues of the partly mature corn stalks.

Here in Hawaii, Walker (6) working at Pioneer Mill Company, reported a series of determinations of the phosphate content of the crusher juice. The samples reported covered both the upper fields, where it was believed phosphoric acid fertilization was required, and the lower land where the supply of phosphates was considered to be adequate. From this data, Walker suggested a tentative set of figures prescribing the limits of phosphate content of the juice which might indicate a deficiency or a good supply of phosphates in the soil. This work on the phosphate content of the juice has now been taken up on many of the Hawaiian plantations. The results to date indicate that information of considerable value may be obtained as to the phosphate supply of the soil. This is especially true

if phosphate plot tests are carried on in typically good and poor plantation fields, and the juice sampled when the plots are harvested.

The next step was to try to obtain some information as to the potash supply of the soil by determining the potash content of the crusher juice. For this purpose a modification of Sherrill's (5) centrifugal cobaltic nitrite method has been employed as published in the methods for chemical control of the Association of Hawaiian Sugar Technologists, 1924. Certain discrepancies have appeared in the results obtained by this method, especially when it has been further modified in the plantation laboratories. The accuracy of the Sherrill method for this purpose has been questioned, so a comparison of the Sherrill procedure with the official gravimetric chloroplatinic method (1) appeared to be desirable. Certain modifications of the Sherrill method, which have been tried in one of the plantation laboratories, have also been studied.

#### SHERRILL METHOD MODIFIED BY HAWAIIAN TECHNOLOGISTS ASSOCIATION

The Sherrill method, as given on page 54 of the Methods of Chemical Control of the Hawaiian Sugar Technologists Association, 1924, is as follows:

The Sherrill centrifugal method is based upon the relative volume of precipitate in two solutions, one of known potash content.

**Standard 1 Per Cent K<sub>2</sub>O Solution:** Weigh carefully 15.83 gm. of C. P. Potassium Chloride, dissolve in distilled water in a liter volumetric flask, add 8 or 10 drops of glacial acetic acid and dilute to 1000 e.c. with distilled water.

**Sodium Cobaltic Nitrite Solution:** To 225 gm. C. P. sodium nitrite (NaNO<sub>2</sub>), add 400 e.c. distilled water and allow to stand over night with occasional stirring. At the same time dissolve 125 gm. C. P. cobalt acetate in 400 e.c. distilled water. When the sodium nitrite is all dissolved, pour the cobalt acetate into it and mix thoroughly by pouring repeatedly from one beaker to the other. Then dilute to 1000 e.c. with distilled water. This solution keeps very well for several months. A precipitate may form on long standing, but has no harmful effect, as it entirely dissolves when the stock solution is diluted and acidified for use.

Prepare a solution for use by adding to 100 e.c. of the above, 65 e.c. distilled water and 5 e.c. glacial acetic acid and mix by shaking. Remove the gases given off by placing under vacuum for one hour, or by standing over night in a loosely stoppered bottle. Sodium cobaltic nitrite does not keep well after it is acidified, so it is best to make up one day's supply at a time.

**Centrifuge:** Use a Babcock milk testing hand centrifuge with a four tube head fitted with cork liners to take centrifuge tubes of the "Sherrill" potash type. Calibrate the tubes as follows: using a 1 e.c. pipette graduated in 0.01 e.c. transfer 0.3 e.c. of mercury to one tube. The mercury can be made to go down into the stem by using the capillary washing tube. The 0.3 e.c. should fill the tube to the 15 mark. Transfer this mercury through a funnel from one tube to another, and note the necessary corrections for each tube. The capillary washing tube must be small enough to reach to the bottom of the centrifuge tube. It is made by drawing a piece of glass tubing to a sufficiently small diameter. It should be connected to a large wash bottle and is used to wash the precipitates out of the tubes.

**Procedure:** Determine the degree Brix of the juice and from this the specific gravity. To about 500 e.c. of juice add milk of lime to faint phenolphthalein alkalinity. Heat just to boiling and filter through a dry Buchner funnel, using suction. Pipette 150 e.c. of the clarified juice, which must be bright and free from suspended and colloidal matter, into a 400 e.c. beaker. Evaporate to less than 50 e.c. on water bath or hot plate. Trans-

fer to a 50 c.c. volumetric flask, add 2.8 c.c. of glacial acetic acid and make up to 50 c.c. after cooling to room temperature which should be above 72° F.

Transfer 17 c.c. of the sodium cobaltic nitrite solution to each of two centrifuge tubes. Be sure that the stems are full of water and contain no air bubbles, before adding the nitrite solution. To one tube add 5 c.c. of the standard 1 per cent K<sub>2</sub>O solution, and to the other 5 c.c. of the prepared sample. Centrifuge at once for one minute, at 1000 r. p. m. Allow the machine to come to a stop, remove each tube, level the precipitate by tapping the stems gently with the finger, replace in the machine, centrifuge for 15 seconds more and read the volume of the precipitate.

$$\text{Per cent K}_2\text{O} = \frac{50 \times \text{Reading of juice}}{150 \times \text{Sp. Gravity Juice} \times \text{Reading of Standard K}_2\text{O solution}}$$

Juices which are very low in K<sub>2</sub>O, and which do not give a reading sufficiently close to that of the standard, to be reliable, should be run again, using 10 c.c. of the sample in one tube and 5 c.c. of the standard K<sub>2</sub>O solution, with 5 c.c. of distilled water in the other. In this case, divide the figure obtained by the above formula by 2.

The standard K<sub>2</sub>O solution does not give constant readings, due to temperature differences and the age of the sodium cobaltic nitrite solution. Hence it is necessary to run a tube of the standard with every sample, or set of samples. If room temperature is below 72° F., gently heat the cobalt solution to 85°, so that the temperature of the liquid in the tubes will be over 72° when the determination is finished. It is essential that the concentrated sample be bright and contain no precipitated or suspended matter after the acetic acid is added. If this is not the case, further clarification must be obtained by acidifying the filtrate from the lime clarification, heating and again filtering before taking the 150 c.c. for analysis. For comparative purposes, the specific gravity of the juice may be neglected and the results expressed as grams K<sub>2</sub>O per 100 c.c. juice. For a more detailed description of the method and its application to other potash containing materials see "Sugar," Vol. 23, May-June, 1921.

Previous work carried on in this laboratory by Hansson has shown that the Sherrill method is not sufficiently accurate to rely on it for the determination of potash in fertilizer samples. A similar study by McGeorge demonstrated that it could not be used for soil extracts, owing to the interference of soluble minerals and the difficulty of obtaining a solution which would contain approximately 1 per cent K<sub>2</sub>O.

The proposed use of the Sherrill method for the determination of the potash content of the cane juice would not call for the absolute accuracy, which would be necessary in a procedure used in fertilizer control work. The plantation agriculturist is interested in the relative content of potash furnished to the cane plant by his better and poorer soils. So long as a method gives a correct relative measure of the potash present in the juice, it would not be significant if the figure obtained were either slightly higher or lower than the exact amount present. Such a control procedure should give consistent differences from the truth, without too great fluctuations between duplicates, if the results are to be considered reliable.

#### MANIPULATION OF THE SHERRILL METHOD

As a preliminary to the comparison of the Sherrill method with the gravimetric procedure, a careful study was made of the method of manipulation and of the conditions which it is necessary to observe in order to obtain satisfactory duplicate

determinations upon solutions of known potash content. The following points were found to be important:

In preparing the dilute solution of sodium cobaltic nitrite acidified with acetic acid, it is necessary to make a fresh supply of this solution for each day's use. The gases formed upon mixing the above solution must be completely evacuated from the bottle by the use of suction. It is not adequate, as suggested in the method, to allow the solution to stand over night in a loosely stoppered bottle.

The centrifuge should be run at as nearly a constant speed as possible when making the precipitation in the Sherrill tubes. It would probably be desirable to use an electric centrifuge, with steady voltage, in order to obtain uniform packing of the precipitates.

It was found that the precipitates formed by the standard 1 per cent  $K_2O$  solution did not settle so well as those given by the usual cane juices. This made the comparison between the standard and the determination uncertain and difficult. Some of the plantation laboratories have attempted to overcome this difficulty by using a different strength of standard solution. A careful trial of these modifications showed that the standard suggested in the outline, namely 1 per cent  $K_2O$ , is to be preferred. The following slight modification appeared to aid in obtaining concordant results: Transfer 17 c.c. of the sodium cobaltic nitrite solution reagent to each centrifuge tube. Add 5 c.c. of a 1 per cent  $K_2O$  solution, made up from KC1, to one tube and 5 c.c. of solution from each prepared sample, containing approximately 1 per cent of  $K_2O$ , to each of the other tubes. Mix the contents of each tube thoroughly. Centrifuge for one minute at 1000 r. p. m. Free the precipitate adhering to the upper walls of the tubes with a rubber policeman. Add a few drops of ether and centrifuge again for one minute.

#### COMPARISON OF SHERRILL AND GRAVIMETRIC METHODS FOR THE DETERMINATION OF POTASH IN CANE JUICE

A comparison was first made between the determination of potash in a set of juice samples, from one of the Oahu plantations, by the official gravimetric method, and by a modification of the Sherrill. The gravimetric determinations were made in the chemical laboratory of this Station and those by the Sherrill procedure were made in the plantation laboratory. The Sherrill determinations were made by a modification in which a  $\frac{1}{4}$   $K_2O$  solution was used as the standard and the juice sample used was the clarified solution, without further concentration. The comparison of these two sets of analyses is given in Table I. It will be seen that there is a very poor agreement between the two methods. In some cases the variation amounts to as much as 100 per cent difference between the two.

TABLE I

**Comparison of Potash Content of Cane Juice by Gravimetric and Sherrill Methods**

Sample Number	Field Number	Date 1926	Solids by Brix	Per Cent K <sub>2</sub> O		Per Cent K <sub>2</sub> O In Solids Sherrill Modified	Per Cent K <sub>2</sub> O In Solids Plantation Laboratory
				In Juice Gravimetric H. S. P. A. Laboratory	In Solids Gravimetric H. S. P. A. Laboratory		
1	25A-29	June 30	19.30	0.219	1.13	0.71	
2	25A-1	July 2	19.81	0.163	0.82	1.20	
3	25A-1	July 3	19.73	0.204	1.03	2.28	
4	25D-28	June 30	18.38	0.274	1.49	2.40	
5	24A-29	July 1	19.28	0.177	0.92	0.61	
6	24A-2	July 3	18.98	0.195	1.03	0.47	
7	24A-3	July 7	19.18	0.186	0.97	0.31	
8	24B-29	July 1	19.30	0.141	0.73	2.41	
9	24B-1	July 2	19.55	0.146	0.75	0.36	
10	24B-2	July 3	19.62	0.141	0.72	2.35	
11	3D	July 13	19.60	0.151	0.77	0.55	
12	3D	July 14	19.20	0.158	0.82	0.41	
13	3D	July 15	19.20	0.168	0.87	0.66	
14	24B	July 7	20.00	0.156	0.78	...	
15	24A	July 12	20.00	0.180	0.90	0.85	
16	24A	July 13	19.80	0.194	0.98	0.55	
17	24A	July 14	19.00	0.189	1.00	0.78	
18	24A	July 15	19.00	0.189	0.99	0.42	
19	24C	July 9	19.90	0.188	0.94	...	
20	24C	July 10	19.30	0.203	1.05	...	
21	24C	July 14	18.90	0.162	0.86	0.51	
22	25A	July 7	20.60	0.219	1.06	1.71	
23	25A	July 8	20.20	0.195	0.96	2.11	
24	25A	July 9	20.80	0.242	1.16	...	
25	25A	July 10	19.80	0.247	1.25	...	
26	25A	July 12	20.30	0.240	1.18	1.57	

A second set of juice samples was obtained from the same plantation. Upon these samples the potash was determined as before by the gravimetric method. Determinations were also made in this laboratory by the regular Sherrill method, with the slight modification noted earlier in this paper. The results of these determinations are given in Table II, and are compared with the results obtained by the plantation laboratory using the same modification of the Sherrill procedure. It will be seen that there is a fairly good agreement between the gravimetric determinations and those made by the regular Sherrill procedure. The Sherrill determinations would not be satisfactory if one desired an extremely accurate estimation of the potash. For a rapid control method, however, the results indicate that the method is applicable. The results by the plantation modification are slightly better than on the previous set of samples, but there are again a number of cases where the difference between the modified Sherrill determination and the gravimetric amounts to over 100 per cent variation.

A final set of juice samples was obtained from Waimanalo Sugar Company. Here the plantation was not making a determination of potash. All the compara-

tive results were obtained in this laboratory. Determinations of potash were made on all samples by the gravimetric and regular Sherrill methods. On half of the samples, determinations were also made, using the previous plantation modification. The results are given in Table III. There is again a fairly good agreement between the gravimetric results and the regular Sherrill procedure, while the results are less accurate by the modification of the Sherrill test. It should be pointed out that there are a few discordant results obtained by the regular Sherrill procedure, but the number of these discrepancies, in our analyses, is not large. We believe these occasional discrepancies would indicate the desirability of checking any unusual Sherrill determinations, gravimetrically.

#### SUMMARY

A comparison has been made of the determination of potash in cane juice by the official gravimetric method, the regular Sherrill centrifugal procedure and a modification used by one of the plantation laboratories.

In general there was a moderately good agreement, for control purposes, between the gravimetric determinations and the regular Sherrill figures. The plantation modification resulted in a notable loss of accuracy.

Occasional discrepancies between the gravimetric and Sherrill procedure suggest the desirability of occasionally checking unusual results obtained by the Sherrill, with gravimetric determinations.

A few precautions are necessary to ensure accuracy with the Sherrill method. The most important of these were found to be:

The centrifuge should be operated at as near 1,000 revolutions per minute as possible.

The gases formed on mixing the sodium cobaltic nitrite with acetic acid should be evacuated from the container by suction.

A 1 per cent K<sub>2</sub>O solution should be used as the standard with each set of potash determinations.

It was found that the standard determinations frequently do not pack down properly in the tubes. Proper packing was facilitated by rubbing down the upper walls of the vessel with a rubber policeman, after the first period of centrifuging, adding a few drops of ether and centrifuging a second time for one minute.

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TABLE II

## Comparison of Potash Content of Cane Juice by Gravimetric and Sherrill Methods

Sample Number	Field Number	Date 1926	Per Cent K <sub>2</sub> O in Solids Gravimetric H. S. P. A. Laboratory	Per Cent K <sub>2</sub> O in Solids Sherill H. S. P. A. Laboratory	Per Cent K <sub>2</sub> O in Solids Sherill Modified Plantation Laboratory
27	24-C	August 16	0.53	{ 0.61 0.62	0.40
28	3-D	August 16	0.73	{ 0.79 0.79	0.55
29	3-C	August 17	0.59	{ 0.76 0.75	1.39
30	3-D	August 17	0.83	{ 0.77 0.76 0.85	1.10
31	3-D	August 19	0.63	{ 0.66 0.70 0.78	1.13
32	3-C	August 19	0.52	{ 0.56 0.58	0.63
33	3-C	August 19	0.70	{ 0.74 0.74	0.42
34	3-D	August 19	0.70	{ 0.86 0.79	0.60
35	3-C	August 20	0.61	{ 0.69 0.72	0.68
36	C	August 21	1.03	{ 1.17 0.99	0.76
37	C	August 21	1.00	{ 1.01 1.04	0.74
38	3-C	August 21	0.70	{ 0.90 0.92	0.83
39	C	July 24	{ 1.01 1.02	{ 1.05 1.08 1.08	0.51
40	3-C	July 24	{ 0.80 0.80	{ 0.73 0.76 0.79	0.33
41	25-C	July 24	{ 1.01 1.02	{ 0.84 0.91 0.91	0.33
42	3-C	July 26	{ 0.81 0.82	{ 0.86 0.85 0.88	0.85
43	25-C	July 26	{ 0.85 0.86	{ 1.02 1.04 1.12	0.68
44	3-C	July 28	{ 0.83 0.81	{ 0.72 0.83 0.90	1.00
45	25-C	July 28	{ 1.24 1.22	{ 1.07 1.11 1.21	0.88
46	25-C	July 29	{ 1.10 1.10	{ 1.11 1.18 1.23	0.41
47	25-C	July 30	{ 1.16 1.15	{ 1.09 1.17 1.20	0.97
48	13-C	August 18	{ 1.55 1.56	{ 1.75 1.81 1.93	1.19
49	13-C	August 19	{ 1.46 1.46	{ 1.65 1.77 1.93	1.09
50	13-C	August 20	{ 1.61 1.60	{ 1.54 1.62 1.75	1.01

TABLE III

## Comparison of Potash Content of Cane Juice by Gravimetric and Sherrill Methods

Sample Number	Field Number	Date 1926	Per Cent K <sub>2</sub> O in Solids Gravimetric H. S. P. A. Laboratory	Per Cent K <sub>2</sub> O in Solids Regular Sherrill Method H. S. P. A. Laboratory	Per Cent K <sub>2</sub> O in Solids Modified Sherrill Method H. S. P. A. Laboratory
1	Waimanalo	September 1	1.05	{ 1.06 1.10	{ 1.27 1.29
2	22D	September 1	0.98	{ 0.91 0.95	{ 1.12 1.14
3	22D	September 1	0.85	{ 0.79 0.61	{ 0.72 0.80
4	22D	September 1	0.84	{ 0.76 0.81	{ 0.86 1.16
5	22D	September 1	1.08	{ 1.10 1.11	{ 1.18 1.57
6	22D	September 1	1.20	{ 1.13 1.15	{ 1.21 1.60
7	22D	September 1	0.99	{ 0.94 0.93	{ 1.57 1.57
8	22D	September 1	0.93	{ 0.91 0.88	{ 1.54 1.54
9	22D	September 1	0.99	{ 0.88 0.90	{ 1.51 1.51
10	22D	September 1	2.04	{ 2.00 1.94	{ 2.48 2.69
11	22D	September 1	1.30	{ 1.28 1.25	{ 1.57 1.79
12	22D	September 1	1.26	{ 1.19 1.14	{ 1.48 1.69
13	22D	September 1	0.89	{ 1.00 0.90	{ 1.18 1.27
14	22D	September 1	0.91	{ 0.85 0.89	{ 1.07 1.23
15	22D	September 1	1.33	{ 1.25 1.13	{ 1.21 1.60
16	22D	September 2	1.37	{ 1.05 0.99	{ 1.36 1.44
17	22D	September 2	0.89	{ 1.52 1.28	
18	22D	September 2	0.88	{ 1.02 0.98	
19	22D	September 2	0.76	{ 0.98 0.89	
20	22D	September 2	0.76	{ 1.30 1.31	
21	22D	September 2	1.25	{ 1.07 1.07	
22	22D	September 2	0.95	{ 0.83 0.80	
23	22D	September 2	1.88	{ 1.62 1.65	
24	22D	September 2	1.20	{ 0.74 0.75	
25	22D	September 2	0.99	{ 0.79 0.81	
26	22D	September 2	0.85	{ 0.54 0.48	
27	22D	September 2	1.17	{ 0.56 0.62	
28	22D	September 2	1.35	{ 0.95 1.01	

# Report on the Treatment of Settlings and the Oliver Filter

By H. F. BOMONTI

The following is a report on the work done during the past year at the Oahu Sugar Company, Limited, in connection with the Oliver Filter. The first part is devoted to the presentation and discussion of the data on the treatment of settlings. The second part of the report gives the operating data secured during a two months' run of the Oliver Filter and also an estimate of the savings which might be realized by a complete installation of Oliver Filters at the Oahu Sugar Company, Limited.

## PART I

### THE TREATMENT OF SETTLINGS

The application of the Oliver Filter to the filtration of settlings depends on the chemical treatment of the settlings. The purpose of the chemical treatment of the settlings is threefold:

First, to improve the filtrability of the settlings to such an extent that a cake of suitable thickness will be formed on the Oliver Filter within a few minutes time.

Second, to produce a permeable cake so that sufficient wash water can be applied within a few minutes to reduce the polarization to a reasonable degree.

Third, to produce a cake which is coherent so that when it is discharged from the filter it will leave the cloth clean.

#### *The Borden Treatment:*

John F. Borden, of the Oliver Continuous Filter Company, developed a treatment in 1925 at the Oahu Sugar Company which meets these requirements. This treatment, which the writer calls the "Borden Treatment," is carried out in the following manner: The settlings are first limed to 8.5-8.6 pH. Phosphoric acid is added until the pH of the settlings is reduced to 6.8 pH. Phosphoric acid or acid phosphate can be used with practically the same results. Double superphosphate, which is the cheapest form of acid phosphate salt, was used at the Oahu Sugar Company.

The following points have been studied in connection with the Borden treatment:

1. The effect on the filtrability of the treated settlings when the final pH is either higher or lower than 6.8 pH.
2. The change in  $P_2O_5$  concentration of the filtrate from treated settlings with changes in pH.

3. The shape of the titration curve secured when double superphosphate solution is added to limed settlings.
4. The effect of mechanical handling on the filtrability of treated settlings.
5. The effect of temperature of the treated settlings on the filtrability.
6. The effect of the degree of vacuum on the volume of filtrate secured in a given time cycle, and also on the ease with which the cake leaves the cloth.
7. The effect produced by repeating filtration tests without washing the cloth after each test.
8. The influence of the composition of the suspended solids in settlings on the weight of the cake formed during a given time cycle.
9. The effect of the Borden treatment on the purity of the filtrate.
10. The accuracy of the pH control of the treated settlings.

*Experimental Filter Unit:*

The experimental filter unit which was used in making these comparative tests, has a filtering surface of one-half square foot. It consists simply of two parts, both circular in shape, with the filter cloth placed between them and clamped together. The vacuum is applied to the lower half in which the filtrate accumulates and is drained into a glass receiver. A wire screen covers the top of the lower half which supports the filter cloth. The upper half is cylindrical in shape and simply holds the settlings during the filtration. A vacuum regulator is in the line so that any vacuum can be maintained. A piece of 10 oz. duck filter cloth was used in all the tests, the cloth being washed after each test.

In all the comparative filtration tests the following procedure was used:

The settlings were poured into the upper half of the filtering unit, filtered for two minutes at 10 inches vacuum; the excess settlings were then poured out and the cake which had been deposited on the cloth was allowed to dry out for two minutes at 15 inches vacuum. The volume of filtrate in the glass receiver was measured. The cake was weighed and the thickness measured. The ease with which the cake left the cloth was noted. The pH of the filtrate was determined with the Experiment Station color charts. Other observations which were desirable at times were made.

*The Effect on the Filtrability of the Borden Treated Settlings When the Final pH is Either Higher or Lower than 6.8 pH:*

Previous tests made by Mr. Borden indicated that the most satisfactory pH to conduct his treatment was 6.8. The following tests were made to study this point. Settlings were first limed to 8.4-9.2 pH; then acidified with varying amounts of the double superphosphate, so that the final pH values were above 6.9, between 6.6-6.8 pH and below 6.6 pH. A filtration test was made on the untreated, limed and each of the treated settlings. These data have been arranged in the following tabulation:

TABLE I

	Untreated		Limed		Acidified Above 6.9 pH		Acidified 6.6-6.8 pH		Acidified Below 6.6 pH	
	pH	Volume of Filtrate ccs.	pH	Volume of Filtrate ccs.	pH	Volume of Filtrate ccs.	pH	Volume of Filtrate ccs.	pH	Volume of Filtrate ccs.
	7.4	650	9.2	900	7.4	950	6.7	850	...	....
	7.9	620	8.5	775	...	....	6.7	940	6.3	900
	7.3	450	8.7	950	7.0	1050	6.6	1100	...	....
	7.3	400	8.5	940	7.0	1280	...	....	6.4	1200
	...	....	8.8	1150	7.6	1320	6.6	1350	6.4	1300
	7.2	475	8.5	900	7.6	1380	6.8	1350	6.3	1380
	7.6	450	8.8	600	7.6	1200	6.6	1500	...	....
	7.6	450	8.4	1360	7.5	1610	6.8	1700	...	....
	...	...	8.4	840	7.0	1150	...	....	6.2	1150
	...	...	8.4	450	7.3	620	...	....	6.5	730
Averages	7.5	500	8.7	918	...	....	...	....	...	....
"	...	...	8.6	899	7.3	1173	...	....	...	....
"	...	...	...	....	7.5	1250	6.7	1310	...	....
"	...	...	...	....	...	....	6.7	1210	6.3	1193

The averages were made in the following manner: Figures in column 1 were averaged in the regular way. To get an average of column 2 comparable to column 1, only those figures were used which had a corresponding result in column 1. This same method was applied to all the other columns.

Comparing these results to the filtrability of untreated settlings the following increases in per cent filtrability have been calculated:

TABLE II

	pH	Per Cent Increase in Filtrability
Untreated settlings.....	...	....
Limed settlings .....	...	83.6
Treated settlings at.....	7.5	139.6
Treated settlings at.....	6.7	151.1
Treated settlings at.....	6.3	147.6

The difference in the filtrability between 7.30 pH and 6.7 pH is relatively small. The chief objection to a 7.3 pH of the treated settlings is that the cake does not seem to leave the cloth as free as it does when the pH is 6.8. This, of course, is a very important point which cannot be neglected, because the success of the filter depends upon the ease with which the cake leaves the cloth. When the settlings are acidified to pH values below 6.7, they tend to show a reduction in the filtrability. While this is undesirable, there are objections which are more important than this. First, we have the possibility of inversion of sucrose at lower pH values. Naturally, as the pH is reduced below 6.8 pH, inversion will become a serious factor even at the temperatures and time intervals involved. Then, too, we have found that the phosphates become more soluble at 6.5 pH.

There is a rapid increase in phosphate below this pH. If such a condition existed, the filtrate would have to be returned to the mixed juice and be resettled to avoid scaling in the evaporators and the formation of a precipitate. Reactions below 6.8 pH are to be avoided at all times in the Borden treatment.

*The  $P_2O_5$  Content of the Filtrate from "Borden Treated Settlings":*

A number of tests were made to determine the pH at which the  $P_2O_5$  content of the filtrate from the Borden treated settlings begins to increase. For if the phosphate increased to any extent at 6.8 pH, then a precipitate would be formed on mixing with the clarified juice of a higher pH. Such a condition would be very undesirable. It would necessitate the returning of all the filtrate to the mixed juice to be resettled. The results have been tabulated below:

TABLE III

Filtrate from "Borden Treated Settlings."	
pH	Per Cent $P_2O_5$
7.5	.005
7.2	.005
7.1	.005
7.0	.005
6.9	.005
6.7	.007
6.6	.007
6.4	.015
6.3	.025
6.0	.035
5.8	.085

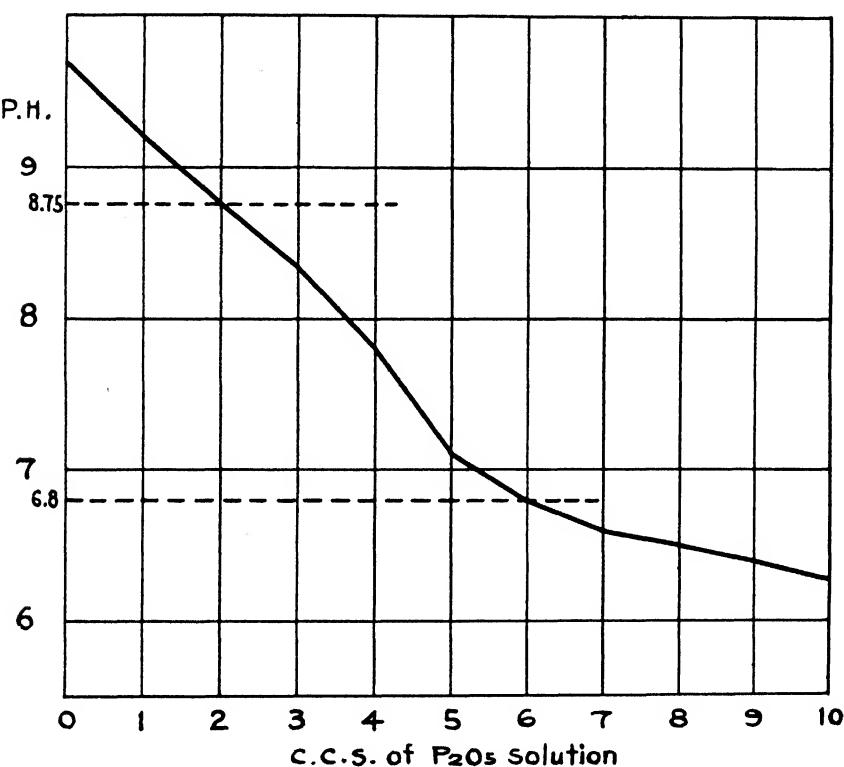
From these data, we can conclude that below 6.6 pH the  $P_2O_5$  content of the filtrate increases quite rapidly. In the Borden treatment, the pH of the settlings is 6.8, so that with careful control no increase in  $P_2O_5$  should be secured. The filtrate can be safely mixed with the clarified juice without forming a precipitate or increasing the scale in the evaporators. These conclusions have been substantiated by actual factory practice. Samples of filtrate which were composited over a long period of time (12 hours) did not show any increase in  $P_2O_5$ , showing that the control was maintained within satisfactory limits.

*The Titration Curve:*

When limed settlings are acidified with a double superphosphate solution, the decrease in pH of the treated settlings will not be proportional to the quantity of the double superphosphate added. Thus, if we take a given quantity of settlings, about 40 c.c. and add c.c. portions of a weak double superphosphate solution to the limed settlings and determine the pH after the addition of each portion of double superphosphate, this will give us a series of pH values and the corresponding c.c. of reagent. Plotting these data on cross section paper and drawing a smooth curve through the points, will give a titration curve. From the shape

of such a curve we can predict whether a 6.8 pH as is desirable in the Borden treatment, can be easily controlled.

Such data as described above were determined on limed settling and plotted in a graph (Graph 1). The shape of the curve above 7.0 pH is fairly steep. This means that with relatively small quantities of reagent added to the settling, comparatively large decreases in pH are secured. Below 7.0 pH the curve shows a very pronounced flattening out, which means that considerably smaller changes in pH are secured with the same amount of double superphosphate solution, so that 6.8 pH which is on the flat portion of the curve should be easily maintained with a suitable indicator. When a small excess or deficiency of reagent is added in trying to acidify to 6.8 pH, the pH actually secured will not be far from 6.8.



Graph 1

The following data taken from Graph 1, show the distribution of the double superphosphate when settling limed to 8.75 pH are acidified to 6.8 pH:

From 8.75 to 8.35 pH requires 25 per cent of the total double superphosphate.  
 From 8.35 to 7.75 pH requires 25 per cent of the total double superphosphate.  
 From 7.75 to 7.10 pH requires 25 per cent of the total double superphosphate.  
 From 7.10 to 6.80 pH requires 25 per cent of the total double superphosphate.

If the settling are acidified to 6.5 pH, it would require 50 per cent more double superphosphate to reduce the pH from 6.8 to 6.5.

*Mechanical Handling of Settlings Before Filtration:*

The equipment used in treating all the settlings consists of three tanks placed immediately below the settling tanks. These mud tanks each have a capacity of 350 cubic feet. There is a propeller mounted in each tank revolving at the rate of 40 r.p.m. The propellers are in motion continuously. A small sample line runs from each tank through a pump to the treating station above. Suitable floats are arranged to indicate when a tank is full. A pressure gauge on the pump feed line indicates when the tank is empty. Recording thermometers are mounted on two of the tanks which not only record the temperature of the settlings but also give a count of the number of tanks filled each day.

The treating station consists of two rectangular boxes, the one for the milk of lime, the other for the double superphosphate solution. Each box is fitted with three drains, one leading to each tank.

The double superphosphate solution is prepared in a wooden mixing tank. It is simply made by mixing double superphosphate with water. The solution is kept in continuous motion to prevent the heavy insoluble matter from settling out. With this arrangement the operator limes the settlings to the desired pH and then acidifies with the double superphosphate solution to 6.8 pH.

The treated settlings are pumped through centrifugal pumps to the filters. These treated settlings are sometimes allowed to remain in these tanks for a half hour or more. During this time they are subjected to the constant beating of the propeller, and receive a still further beating when they are pumped by the centrifugal pumps.

The effect of this mechanical handling of the settlings on the filtrability is shown in the following tabulation. The comparison is made between bucket treated settlings and tank treated settlings:

TABLE IV

Bucket Treated Settlings			Tank Treated Settlings			Per Cent Decrease in Filtrability
pH	Volume of Filtrate ccs.	Thickness of Cake	pH	Volume of Filtrate ccs.	Thickness of Cake	
7.0	1280	5/16"	6.7	940	1/4"	26.5
6.7	1060	3/16"	6.8	700	1/8"	34.0
6.7	1550	1/4"	6.8	1000	3/16"	35.5
6.8	1600	5/16"	6.8	1240	1/4"	22.5
6.9	1600	1/4"	6.7	1200	3/16"	25.0
6.8	1700	3/16"	6.9	1140	1/8"	33.0
7.0	1060	3/16"	6.8	700	1/8"	34.0
6.7	1250	1/4"	7.1	900	.....	26.0
7.0	1060	1/4"	6.8	700	1/8"	34.0
6.8	1050	1/4"	6.9	900	1/4"	14.0
7.3	1650	3/8"	7.3	950	1/4"	42.0
6.8	1450	3/8"	7.0	700	3/16"	52.0
Avg.	6.88	1/4"	6.88	925	3/16"	32.0

Under the heading "Bucket Treated Settlings" are the results secured when small portions of the settlings were carefully treated without any violent mixing. These results represent the maximum attainable with the Borden treatment.

Under the heading "Tank Treated Settlings" are the results secured when the settlings have been treated on a large scale with the mechanical equipment originally designed for this purpose. The average of the twelve tests given in the above tabulation shows a reduction in filtrability amounting to 32 per cent. Individual tests vary from 14 per cent to 52 per cent.

In order to determine the cause of this reduction in filtrability a number of tests were carried out. The first point to be investigated was whether this reduction in the filtrability of the tank treated settlings was of a permanent nature or whether after standing for a reasonable length of time the filtrability would be restored to that of the bucket treated settlings:

TABLE V

Treatment	pH	Vol. of Filtrate	Temperature
Bucket treated settlings.....	6.8	1080 c.e.	77° C.
After standing $\frac{1}{2}$ hour.....	...	1050 c.e.	76° C.
Tank treated settlings.....	7.0	850 c.e.	77° C.
After standing $\frac{1}{4}$ hour.....	6.9	800 c.e.	77° C.
After standing $\frac{1}{2}$ hour.....	6.8	800 c.e.	77° C.

The results of another test similar to the one cited above follow:

TABLE VI

Treatment	pH	Vol. of Filtrate	Temperature
Bucket treated settlings.....	6.7	950 c.e.	79° C.
After standing $\frac{1}{4}$ hour.....	...	960 c.e.	77° C.
Tank treated settlings.....	6.8	700 c.e.	76° C.
After standing $\frac{1}{4}$ hour.....	...	700 c.e.	73° C.

In the above tests the settlings were stirred only during the treatment. There was no material change in the filtrability either in the bucket or tank treated settlings on standing without agitation. From these tests, we can conclude that this reduction in filtrability of the tank treated settlings is permanent.

In the following series of filtration tests, comparative data were secured between bucket treated settlings, tank treated, and bucket treated settlings which were subjected to rapid stirring during the treatment. Such data were secured for the purpose of finding out what effect rapid stirring had on the filtrability of the treated settlings. The results of five tests are given in the tabulation below:

TABLE VII

Bucket Treated			Tank Treated			Bucket Treated*		
pH	Volume of Filtrate	pH	Volume of Filtrate	Per Cent Reduction	pH	Volume of Filtrate	Per Cent Reduction	
6.9	1100 c.c.	7.0	950 c.c.	13.6	6.9	950 c.c.	13.6	
7.2	1200 c.c.	6.9	1000 c.c.	17.0	6.9	1050 c.c.	12.5	
6.8	1150 c.c.	7.0	850 c.c.	26.1	6.8	900 c.c.	22.0	
6.7	850 c.c.	6.8	700 c.c.	17.6	6.8	725 c.c.	14.7	
6.7	1300 c.c.	6.8	975 c.c.	25.0	6.8	1050 c.c.	19.2	
Average ...	6.9	1120 c.c.	6.9	895 c.c.	20.0	6.8	935 c.c.	16.5

There is a reduction in the filtrability of the bucket treated settling which were subjected to rapid stirring. The average of five tests is 16.5 per cent; this is almost equivalent to the reduction produced in the tank treated settling which amounts to 20.0 per cent. From this, we may conclude that the reduction in the filtrability of the tank treated settling is due to the severe stirring action of the propeller and the beating effect of the centrifugal pumps.

The double superphosphate solution used in acidifying the settling contained large quantities of insoluble matter which were in a very fine state of division. The following tests were made to determine whether in the absence of this insoluble matter, rapid stirring would still produce this reduction in filtrability. A portion of double superphosphate solution was filtered through filter paper to remove the insoluble matter. Comparative tests were then made simply between bucket treated settling which were gently mixed, and bucket treated settling which were violently stirred:

TABLE VIII

Treatment	pH	Volume of Filtrate	Per Cent Reduction
Bucket treated, gentle mixing.....	6.8	1100 c.c.	...
Bucket treated, violent mixing.....	6.8	1050 c.c.	4.6
Bucket treated, gentle mixing.....	6.8	1240 c.c.	...
Bucket treated, violent mixing.....	6.8	1175 c.c.	5.2

The average reduction for the two tests is 4.9 per cent. In the presence of the insoluble impurities, there was an average reduction of 16.5 per cent as given in Table VII. From these data, the conclusion has been drawn that the reduction in filtrability in the tank treated settling is due to the stirring action and is greatly increased by the finely divided impurities which are introduced with the double superphosphate solution. The remedy lies in gentle mixing while treating the settling. As soon as the treatment is completed, the stirring should be stopped.

For these reasons, the settling which were sent to the Oliver Filter were treated separately in the following manner: A tank having two compartments,

\* These were bucket treated as in column 1, but were subjected to severe stirring during the treatment.

each of 40 cubic feet capacity, was mounted in front of the filter. The unlimed settling were pumped with a plunger pump from a receiving tank into this small tank. They were then treated in the same way but were mixed by hand. The treated settling were fed into the filter by gravity. A recording thermometer was mounted on this tank which gave the temperature and also a count of the number of tanks filled. It also gave a record of the actual operating time. While this was a temporary arrangement it clearly demonstrated the conditions which must be met to do the treating on a large scale mechanically. With this change in the mechanical handling of the treatment of the settling, no further difficulties were encountered by the Oliver Filter.

*The Effect of the Temperature on the Rate of Filtration:*

A large portion of treated settling was heated up to 85° C. Filtration tests were made at a series of temperatures as the settling cooled off. The data are tabulated below:

TABLE IX

Temperature of Settling When Filtered	Volume of Filtrate c.c.
85 ° C.	750
80 ° C.	750
73.5 ° C.	720
66.0 ° C.	710
61.0 ° C.	700
57.0 ° C.	710
53.0 ° C.	705
49.0 ° C.	675
45.0 ° C.	640

There is a relatively small difference in the volume of filtrate between 85° C. and 53° C. Under 53° C. there is a more pronounced decrease in the volume of the filtrate. From further tests which were made the volume of filtrate does not increase materially when the temperature of the settling is above 85° C. These tests have been carried to as high as 95° C. The temperature of the settling in the Oliver is between 85° C. and 90° C. At these temperatures the inversion velocity has been materially reduced so that with the pH of the settling at 6.8, the inversion of sucrose is negligible. The temperature is below the flash point for the vacuum carried.

*The Effect of Varying the Vacuum on the Volume of the Filtrate:*

In the standard method of comparing the filtrability of the settling as developed by Mr. Borden, the direct filtration is carried out at 10" vacuum, and dried out at 15" vacuum. A number of tests were made on a large sample of treated settling at widely varying vacuums, as indicated in the tabulation:

TABLE X

Filtering Vacuum	Drying Vacuum	Volume of Filtrate
10" (Standard)	15" (Standard)	1000 c.e.
27"	27"	1000 c.e.
7½"	7½"	940 c.e.
5"	5"	950 c.e.
3½"	3½"	850 c.e.
2"	2"	800 c.e.
5"	10"	900 c.e.
3½"	5"	850 c.e.

There is no increase in the volume of settlings filtered at vacuums above 10 inches. At the lower vacuum there is a gradual falling off amounting to 20 per cent at 2" vacuum. There was a pronounced difference, however, in the way the cake leaves the cloth. At the high vacuum, the cake stuck to the cloth so that when it was removed the cloth was dirty. With lower vacuums the cake was still wet, yet it was coherent enough so that it left the cloth clean.

The ease with which the cake leaves the cloth is very essential to the successful operation of the filter. While a lower vacuum might reduce the capacity about 5-10 per cent, the cake will be easily discharged and leave a clean filtering surface. Under such conditions a high filtering rate may be secured over a long period of time with less frequent stopping to wash the cloth.

*The Effect of Repeating the Filtration of Settlings on the Experimental Unit Without Washing the Cloth After Each Test:*

Two buckets of settlings were limed to 8.6 pH and acidified with double superphosphate to 6.8 pH. The regular method of making these tests was followed, that is, the settlings were filtered at 10" vacuum and dried out at 15" vacuum. The cake was removed from the cloth and the test repeated on the same settlings without washing the cloth:

First run .....	1050 c.e. filtrate
Second run .....	1100 c.e. filtrate
Third run .....	1080 c.e. filtrate
Fourth run .....	975 c.e. filtrate
Fifth run .....	900 c.e. filtrate

After the third test there is a dropping off in volume of the filtrate, showing that the cloth was gradually becoming dirty.

Settlings which had been treated in the regular factory equipment were also tested. These settlings had been subjected to severe stirring and pumping through a centrifugal pump. The same method of procedure was followed as described above. The results follow:

First run .....	850 c.e. filtrate
Second run .....	650 c.e. filtrate
Third run .....	625 c.e. filtrate
Fourth run .....	350 c.e. filtrate

After the fourth run the cloth was very dirty, so that the fifth run was practically nothing.

A third test was made on settlings which were treated as described in test 1. The method of filtering was modified to the extent that the filtration was carried out at 5" vacuum and the cake dried out at 5" vacuum.

First run .....	800 c.c. filtrate
Second run .....	750 c.c. filtrate
Third run .....	700 c.c. filtrate
Fourth run .....	800 c.c. filtrate
Fifth run .....	850 c.c. filtrate
Sixth run .....	800 c.c. filtrate
Seventh run .....	800 c.c. filtrate
Eighth run .....	775 c.c. filtrate

Using the regular method of making filtration tests on the settlings in test 3, the volume of the filtrate was 830 c.c.

The results given in test 3 show that with a reduced vacuum on filtration there is a very pronounced tendency for the cloth to remain clean. This is undoubtedly due to the fact that the cake is not deposited on the cloth as firmly as it is at higher vacuums, so that when it is discharged from the cloth it will leave the cloth freely. Test 3, also shows that the volume of filtrate for a given cycle is almost the same whether the vacuum is 5" or 10".

#### *The Influence of the Composition of the Suspended Solids in the Borden Treated Settlings on the Weight of Cake Formed:*

The object of the following series of experiments was to find out, if possible, what factors determined the weight of cake formed in a given filtering cycle. These tests were made under identical conditions; the only difference being in the character of the settlings filtered. The filtration data together with the analytical data have been arranged in the following tabulation:

TABLE XI

Date of sample.....	3-10-26	1-29-26	2-29-26	1-26-26	1-29-26	2-9-26	2-3-26	2-24-26
Weight of cake gms.....	460	372	348	288	188	195	145	136
Weight of solids in cake gms. ....	69.4	67.0	60.2	47.7	37.6	35.0	29.0	28.0
Volume of filtrate c.c....	1000	1640	1350	1590	1200	725	1600	900
Thickness of cake, in....	7/16	3/8	5/16	5/16	1/4	3/16	1/8	1/8
Vol. of filtrate/Wt. of cake .....	2.2	4.4	3.9	5.5	6.4	3.7	11.0	6.6
Suspended solids per cent settlings .....	5.0	3.3	3.6	2.9	2.6	3.8	1.7	2.6
Fiber per cent settlings..	1.81	1.20	1.26	1.01	0.86	1.19	.56	0.68
Nitrogen per cent set- tlings .....	.071	.069	.062	.054	.069	.033	.048	
Ether soluble per cent settlings .....	0.33	0.38	.46	.29	.29	.44	0.24	0.33
Ash per cent settlings...	1.26	.84	.98	.73	.66	1.19	0.45	0.74
Silica per cent settlings.	0.20	0.15	.15	.16	.13	.23	.10	.12
P <sub>2</sub> O <sub>5</sub> per cent settlings... ....	0.15	.19	.13	.12	.20	.09	.12	
Ratios								
Ash/Fiber .....	69.4	69.6	77.4	72.4	76.7	98.7	81.4	108.6
Ether Soluble/Fiber ....	18.2	31.2	36.6	28.4	34.0	36.6	43.5	49.6
Nitrogen/Fiber .....	5.85	5.41	6.12	6.26	5.71	6.02	7.10	
SiO <sub>2</sub> /Fiber .....	11.0	12.5	11.8	16.0	15.5	19.0	17.3	17.5
SiO <sub>2</sub> /Ash .....	15.9	18.0	15.3	22.1	20.1	19.3	21.2	16.1
P <sub>2</sub> O <sub>5</sub> /Ash .....	...	17.9	19.5	18.0	18.0	17.0	20.8	16.3

**Cake Analysis (Sucrose free dry basis)**

Fiber .....	36.2	36.4	35.3	34.8	33.1	31.7	32.7	26.1
Ether soluble .....	6.60	11.39	12.9	9.89	11.26	11.6	14.22	12.66
Nitrogen .....	2.15	1.91	2.13	2.08	1.81	1.97	1.84	
Ash .....	25.2	25.27	27.32	25.2	25.4	31.3	26.6	28.34
Silica .....	4.00	4.55	4.18	5.57	5.13	6.04	5.07	4.56
P <sub>2</sub> O <sub>5</sub> .....	....	4.52	5.33	4.51	4.56	5.33	5.64	4.62

**Analysis of the Filtrate**

pH .....	6.8	7.2	6.9	6.9	7.2	7.0	7.3	6.5
Brix .....	14.0	14.4	14.8	13.8	13.8	14.4	15.2	14.4
Ash .....	....	0.33	....	0.29	0.33	....	0.34	....
Chlorides .....	....	.047	....	.024	.049	....	.062	....
Sulphates .....	....	.055	....	....	.040	....	.048	....

These data have been arranged in the order of the weight of suspended solids in the cake. Comparing the weight of solids in cake for the different samples, we find that there is a wide variation in the amount of cake solids, likewise there is a wide variation between the volume of the filtrate for the different samples. While there is no direct relation between volume of the filtrate and the weight of cake, there is, as might be expected, a definite relation between the ratio of the volume of filtrate to weight of cake and the suspended solids in the settlings. These values have been plotted in Graph 2.

With settlings high in suspended solids, the ratio of the volume of filtrate to the weight of cake decreases. Such a condition would be most favorable to the operation of the Oliver Filter.

The significant data in the table are the relation between per cent fiber in cake and the weight of cake solids. With one exception these figures are very consistent. These data have been tabulated separately as follows:

Grams Cake Solids	Per Cent Fiber in Cake	SiO <sub>2</sub> /Fiber
69.4	36.2	11.0
67.0	36.4	12.5
60.2	35.3	11.8
47.7	34.8	16.0
37.6	33.1	15.5
35.0	31.7	19.0
29.0	32.7	17.3
28.0	26.1	17.5

As the per cent fiber in the cake decreases the weight of cake solids formed decreases. For this reason the writer considered the fiber as the filter aid. There is a fairly consistent relation between the silica in the cake and the weight of the cake solids. As the cake solids decrease the SiO<sub>2</sub>/Fiber ratio shows a fairly consistent increase. This indicates that some form of silica in the settlings retards the filtration. There are other constituents in the settlings which undoubtedly have an effect on the filtration.

**Ratio :-**  
 $\frac{\text{Vol. of filtrate}}{\text{Wt. of cake}}$

12

10

8

6

4

2

0



% Suspended Solids in settings

Graph 2

*The Effect of the Borden Treatment on the Purity of the Filtrate from the Oliver:*

A number of tests were made to compare the purity of the filtrate from the settlings before and after treatment. This would show whether the treatment reduced the purity of the filtrate. The average of eighteen experiments follows:

	Brix	Polarization	Purity
Filtrate from untreated settlings.....	14.25	12.34	86.72
Filtrate from settlings after treatment.....	14.16	12.25	86.51

The purity of the filtrate from the treated settlings is 0.21 less than the purity of the filtrate from the settlings before treatment. This difference is considerably smaller than would be encountered in the former practice of liming the settlings before filtration.

In the following series of laboratory tests, the purity of the undiluted filtrate and the purity of the filtrate which included the cake washings were compared. The average of five tests is given in the following tabulation:

	Brix	Polarization	Purity
Filtrate from treated settlings.....	13.96	12.14	87.00
Filtrate from treated settlings, including cake washings...	13.56	11.74	86.60

These figures indicate that an overall decrease in purity will amount to about 0.60 between the clarified juice and the filtrate from the Oliver Filter. This is a smaller decrease in purity than is ordinarily secured in the filter press station.

Routine laboratory samples were taken of the Oliver filtrate over a period of three weeks. Due to the fact that the Oliver filtrate is divided into two portions, the one includes all the washings and a part of the filtrate, the other is filtrate only, made it difficult to secure an accurate sample. A grab sample of both portions of the Oliver filtrate was taken hourly and analyzed every six hours. The purity of this sample was compared with the purity of the clarified juice. Comparison was also made of the purity of the filter press juice with the purity of the clarified juice. The filter press juice sample was a grab sample, taken hourly and composited over a six-hour period. *This sample did not contain any washings.* The following tabulation gives the averages for a three weeks period.

	Clarified Juice	Filter Press Juice*	Oliver Filtrate
Brix .....	14.83	13.59	12.22
Polarization .....	12.95	11.83	10.54
Purity .....	87.32	87.05	86.26
Decrease in purity.....	.....	-0.27	-1.06

The decrease in purity between clarified juice and filter press juice amounts to -0.27. This agrees very well with the figure --0.21 given on the previous page which was secured with small tests. The purity of the Oliver filtrate is 1.06 less than the purity of the clarified juice. Inspection of the individual figures indicates that the results are influenced to a large extent by the sampling. As explained before, it was impossible to secure a truly representative sample of the Oliver filtrate including the washings, so that this decrease in purity of 1.06 would be materially reduced, as is indicated by the purity of the filtrate including the washings given on the previous page.

#### *The pH Control of the Treatment:*

Experiments have shown that the most desirable pH for the Borden treatment of settlings is 6.8. At times, higher pH values will give good results. However, such conditions cannot be anticipated, so that the lower pH is used.

Brom thymol Blue indicator is used to control the reaction of the treated settlings. In alkaline solutions this indicator is blue, while in acid solutions, it becomes light green to yellow. At 6.8 pH Brom thymol Blue is a very distinctive dark green color. So that when limed settlings are acidified, a point will be reached where a drop of Brom thymol Blue indicator added to a small portion of the settlings in a casserole, will turn dark green. The settlings will be close to or at 6.8 pH. This end point is easy to detect.

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\* This sample does not contain any press washings.

The following tabulation of pH values covers a period of 22 days. Each daily average represents 24 separate samples. Under the headings maximum and minimum are the highest and lowest pH values which were reported by the laboratory for the day. Most of the time the pH of the Oliver filtrate was down to 6.8-6.9 pH. The average of 528 determinations made during 22 days operation is 6.89 pH. The average maximum is 7.21 pH, and the average minimum is 6.61 pH. From the data on the control of the Oliver treated settling, we can conclude that the method of control is practical.

TABLE XII

pH of Oliver Filtrate				pH of Oliver Filtrate			
Date	Average	Maximum	Minimum	Date	Average	Maximum	Minimum
May 18...	7.01	7.3	6.8	June 1...	6.86	6.90	6.7
19...	7.20	7.8	6.8	2...	6.80	7.0	6.5
20...	6.90	7.5	6.5	3...	6.79	7.00	6.5
21...	7.08	7.5	6.9	4...	6.85	7.00	6.5
22...	6.93	7.4	6.7	5...	6.97	7.6	6.8
25...	6.88	7.22	6.7	7...	7.06	7.5	6.7
26...	6.84	7.1	6.6	8...	6.83	7.2	6.6
27...	6.72	6.9	6.4	9...	6.91	7.5	6.6
28...	6.78	6.9	6.5	10...	6.86	7.0	6.6
29...	6.75	6.9	6.5	11...	6.93	7.4	6.6
31...	6.76	6.9	6.5	12...	6.87	7.2	6.5

## TEST I

Treatment	pH	Volume of Filtrate	Thickness of Cake
Limed settlings .....	8.5	600 c.e.	3/16"
Borden treated settlings.....	6.8	1425 "	3/8"
Sulphured settlings.....	8.5	1125 "	5/16"

## TEST II—Sulphur treatment same as Test I.

Treatment	pH	Volume of Filtrate	Thickness of Cake
Limed settlings .....	8.5	1225 c.e.	....
Borden treated settlings.....	6.8	2000 "	1/2"
Sulphured settlings.....	8.5	1885 "	7/16"

In the above two tests which comprise Experiment 1 the sulphur treated settlings show an improvement in the filtration characteristics which is almost equivalent to the Borden treated settlings. The cake from these sulphured settlings did not leave the cloth very clean.

In Experiment 2 the settlings were simply limed to phenolphthalein neutrality and then sulphured back to 6.7 pH without the addition of any extra lime. A filtration test was made as soon as the treatment was completed, and another test on the same settlings which were allowed to stand for twenty minutes.

## TEST I—Experiment 2

Treatment	pH	Volume of Filtrate
Limed settlings .....	8.8	850 c.e.
Borden treated settlings.....	6.8	1300 "
Sulphured settlings.....	6.7	1400 "
After standng 20 minutes.....	6.7	2100 "

## TEST II—Experiment 2

Treatment	pH	Volume of Filtrate
Limed settlings .....	8.8	560 c.e.
Borden treated settlings.....	6.8	1150 "
Sulphured settlings.....	6.7	1175 "
After standing 15 minutes.....	...	1300 "
After standing 30 minutes.....	...	1480 "

The data in the above two tests show that the filtrability of the sulphured settlings is equal to that of the Borden treated settlings and when the sulphured settlings were allowed to stand for twenty minutes to a half hour, a very pronounced improvement was secured. The cake which was formed in these tests on sulphured settlings left the cloth very free. The time which was necessary to secure the maximum benefits from the sulphur treatment was an undesirable feature.

The above two experiments served as a basis for a more extensive series of tests. In the next series a variety of combinations were tried out.

*Test I.* Settlings limed to neutrality to phenolphthalein and sulphured back to 7.6 pH:

Treatment	pH	Volume of Filtrate	Thickness of Cake
Borden treated settlings.....	6.7	1500 c.e.	5/16"
Sulphured settlings.....	7.6	1250 "	1/4-5/16"
After standing 20 minutes.....	7.6	1475 "	5/16"
After standing 40 minutes.....	7.6	1475 "	5/16"

In this test, the sulphuring was stopped at 7.6 pH. After standing 20 minutes an appreciable improvement in the filtrability is secured, practically equal to that secured by the Borden treated settlings.

*Test II.* This test is similar to Test I, with the exception that the settlings were sulphured to 6.6 pH. A portion was filtered immediately after treating, and at half hour and hourly intervals:

Treatment	pH	Volume of Filtrate	Thickness of Cake
Borden treated settlings.....	6.8	1400 c.e.	5/16"
Sulphured settlings.....	6.6	1350 "	5/16"
After standing 1/2 hour.....	6.6	1675 "	3/8"
After standing 1 hour.....	6.5	1725 "	3/8"

The test made on sulphured settlings immediately after they were treated showed a filtration rate which was almost equal to that of the Borden treated settlings. Standing shows the same pronounced improvement as in the previous tests. The cake in the tests where the settlings were allowed to stand left the cloth very free.

*Test III.* Fifteen grams of hydrated lime were added to 10 liters of limed settlings. These settlings were first limed to neutral to phenolphthalein. They were then sulphured to 6.8 pH and tested immediately. Additional tests were made at one-half hour and three-fourth hour intervals:

Treatment	pH	Volume of Filtrate	Thickness of Cake
Borden treated settlings.....	6.7	1400 c.e.	1/2"
Sulphured settlings.....	6.8	1925 "	3/4"
After standing 30 minutes.....	6.8	2175 "	7/8"
After standing 45 minutes.....	...	2350 "	7/8"

Using this excess lime and sulphuring back to 6.8 pH, produced very free filtering settlings. Even after standing 45 minutes the maximum rate does not seem to have been reached. The cake left the cloth very free. These tests demonstrated that the filtrability of the sulphured settlings was considerably better than that of the Borden treated settlings.

A group of tests similar to those in the preceding experiments were made. Ash analyses were made on the filtrates to find out whether the ash content of these sulphured settlings was materially increased. To ten liters of limed settlings 12 grams of hydrated lime was added. One portion was sulphured back to 8.5 pH, a second portion was sulphured to 7.6 pH, and a third portion was sulphured to 7.0 pH. Samples were taken of the filtrate from untreated settlings and Borden treated settlings.

TABLE XIII

## Experiment IV, Test I

Treatment	pH	Volume of Filtrate	Brix	Per Cent Ash	CaO Per Cent Ash	Ash Per Cent Brix	Per Cent Ash Cl. J. Brix	Increase in Ash
Clarified juice.....	7.5	....	11.0	.26	14.0	2.36	.26	...
Filtrate—Borden treated settlings .....	7.0	1280 c.c.	11.6	.28	12.3	2.41	.26	.00
Filtrate—sulphured set- tlings .....	8.5	1250 "	12.65	.37	24.4	2.92	.32	.06
Filtrate—sulphured set- tlings after $\frac{1}{2}$ hour...	8.5	1450 "	12.35	.38	26.4	3.08	.34	.08
Filtrate—sulphured set- tlings after $\frac{3}{4}$ hour...	8.4	1400 "	12.55	.39	26.1	3.11	.34	.08
Filtrate—sulphured set- tlings after 1 hour....	8.4	....	13.10	.41	23.8	3.13	.34	.08

## Test II

Clarified juice.....	7.6	....	11.8	.29	13.2	2.46	.29	...
Filtrate—Borden treated settlings .....	6.9	1700 c.c.	11.9	.31	12.5	2.60	.31	.02
Filtrate—sulphured set- tlings .....	7.6	2100 "	12.8	.37	18.5	2.89	.34	.05
Filtrate—sulphured set- tlings after $\frac{1}{4}$ hour...	7.6	2300 "	13.2	.37	18.1	2.80	.33	.04
Filtrate—sulphured set- tlings after $\frac{1}{2}$ hour...	7.6	2350 "	13.7	.38	16.9	2.77	.33	.04

## Test III

Clarified juice.....	7.6	....	14.1	.33	12.66	2.34	.33	..
Filtrate—Borden treated settlings .....	7.4	1450 c.c.	14.65	.36	14.63	2.46	.35	.02
Filtrate—sulphured set- tlings .....	7.0	1885 "	15.7	.45	21.83	2.87	.40	.07
Filtrate—sulphured set- tlings after 35 min....	7.0	2270 "	16.25	.45	20.71	2.77	.39	.06
Filtrate—sulphured set- tlings after 1 $\frac{1}{4}$ hours..	7.0	2280 "	16.5	.46	19.70	2.79	.39	.06

There is a pronounced improvement in filtrability in the above tests on sulphured settlings. This increases quite consistently as the pH of the treated settlings is reduced. The effect of standing is also very pronounced in Test II and Test III. The explanation for this marked improvement in the filtrability, when the sulphur treated settlings are allowed to stand for some time, may be that the calcium sulphite precipitate becomes more granular on standing, or that the particles which retard filtration require some time to coagulate. There is a

slight reduction in the ash content of the filtrates from the sulphur treated settlings on standing, which may tend to improve the filtrability.

The increase in ash of the filtrate is an undesirable effect, because such an increase in ash would reduce the purity materially. In Test I, the sulphuring was stopped at 8.5 pH. The filtrate from these sulphured tests shows an increase in ash amounting to .06-.08 per cent. In Test II, the pH of the sulphured settlings was 7.6. There was a material reduction in the increase in ash, amounting to almost 50 per cent. With a further reduction in the pH of the sulphured settlings, the ash increases again to .06-.07 per cent increase in ash. These changes in ash are undoubtedly due to changes in solubility of the lime salts which include calcium sulphite, with changes in pH.

This increase in ash in the filtrate from the sulphured settlings combined with the time required to secure the maximum filtrability makes this treatment unsuitable for practical application. Further tests were made with the purpose of modifying the sulphur treatment, which would either eliminate those undesirable features or reduce them to a negligible degree.

In the following tests, settlings were first limed to neutral to phenolphthalein. Varying amounts of lime were then added and sulphured back to approximately 6.8 pH. Filtration tests were made as soon as the treatment was completed and also after the treated settlings were allowed to stand for various time intervals.

TABLE XIV

## Test I

Grams Lime Added	Treatment	pH	Vol. of Filtrate ccs.	Thickness of Cake
To 10 liters of settlings 15 gms. $\text{Ca}(\text{OH})_2$	Borden treated settlings.....	6.9	1900	1/2"
	Sulphur treated settlings.....	6.8	2450	5/8"
	Sulphur treated settlings after $\frac{1}{2}$ hour ..	6.8	3050	3/4"

## Test II

10 gms. $\text{Ca}(\text{OH})_2$	Borden treated settlings.....	6.7	1650	1/2"
	Sulphur treated settlings.....	7.0	2400	3/4"
	Sulphur treated settlings after $\frac{1}{2}$ hour ..	7.0	2550	7/8"
	Sulphur treated settlings after $\frac{3}{4}$ hour ..	7.0	2600	1"

## Test III

5 gms. $\text{Ca}(\text{OH})_2$	Borden treated settlings.....	6.8	1550	7/16"
	Sulphur treated settlings.....	6.9	2025	11/16"
	Sulphur treated settlings after $\frac{1}{2}$ hour ..	6.9	2200	3/4"

## Test IV

No extra lime added	Borden treated settlings.....	6.8	1625	1/2"
	Sulphur treated settlings.....	7.0	1595	1/2"
	Sulphur treated settlings after $\frac{1}{2}$ hour ..	6.9	1850	5/8"

**Test V**

No extra lime added	Borden treated settlings.....	6.9	1580	.....
	Sulphur treated settlings.....	7.2	2140	.....
	Sulphur treated settlings after $\frac{1}{4}$ hour..	7.2	2350	.....

As the lime was increased in the above group of tests, the filtrability was proportionately increased. The filtrability, however, increased on standing in all cases.

In a preliminary test in which the settlings were first limed to neutral to phenolphthalein, then sulphured back to 6.2 pH and again limed to 7.4 pH, very encouraging results were secured. This treatment was followed in a series of tests, the results of which follow:

TABLE XV

**Test I**

	pH	Volume of Filtrate
Borden treated settlings.....	7.1	1700 c.e.
Sulphured settlings .....	6.6	1675 c.e.
Sulphured settlings limed back to.....	7.2	2075 c.e.
Sulphured settlings limed and standing $\frac{1}{4}$ hour.....	7.2	2125 c.e.

**Test II**

Borden treated settlings.....	6.8	1600 c.e.
Sulphured settlings .....	6.6	1850 c.e.
Sulphured settlings limed back to.....	7.4	2000 c.e.
Sulphured settlings limed and standing $\frac{1}{4}$ hour.....	7.4	2025 c.e.
Sulphured settlings limed and standing $\frac{1}{2}$ hour.....	7.3	2000 c.e.

**Test III**

Borden treated settlings.....	6.8	1340 c.e.
Sulphured settlings .....	6.2	1850 c.e.
Sulphured settlings limed to.....	7.0	2400 c.e.
Sulphured settlings limed and standing $\frac{1}{4}$ hour.....	7.0	2425 c.e.
Sulphured settlings limed and standing $\frac{1}{2}$ hour.....	7.0	2400 c.e.

With this modification in the sulphur treatment, the maximum filtrability is secured as soon as the treatment is completed, as shown by the data in the above tabulation. Even after standing one-half hour, there is practically no increase in the volume of filtrate. Such differences as do exist are easily within the experimental differences of the method.

A further test was made to determine the effect that this modified treatment had on the ash content of the filtrate.

TABLE XVI

Treatment	pH	Volume of Filtrate ccs.	Brix	Ash	CaO Per Cent Ash	Ash Per Cent Brix	Per Cent Ash on Cl. J. Brix	Increase in Ash
Clarified juice .....	6.5	....	11.65	.28	10.25	2.40	.28	..
Sulphured settlings .....	6.6	1300	15.44	.43	16.5	2.79	.33	.05
Sulphured settlings limed back to... 7.6		1750	16.44	.46	18.5	2.80	.33	.05
Sulphured settlings limed back to... 6.9		....	15.19	.43	19.5	2.83	.33	.05

From the results of the above tests, an increase in ash amounting to .05 per cent is secured. This increase in ash will affect the Brix of the filtrate about .1 per cent, resulting in a decrease in purity amounting to about 1.0 per cent on the filter press juice. With the settlings representing about 20 per cent of the mixed juice, an increase of .01 per cent in ash in the evaporator supply juice would be secured. In these experiments, the settlings were usually sulphured at temperatures between 90-100 degrees Centigrade. While no experiments were carried out to determine the most desirable temperature for conducting the sulphur treatment, there are indications that slightly better results will be secured when the temperature of the settlings is close to 100 degrees Centigrade. Further, at these high temperatures, the solubility of the calcium sulphite is reduced to a minimum. The temperature of the settlings as they are discharged from the settling tanks is usually between 93 and 96 degrees Centigrade. These temperatures are sufficiently high to secure good results and also prevent any flashing in the Oliver Filter. The difference in solubility of calcium sulphite between 90 and 100 degrees Centigrade is very small, so that no further increase in ash beyond that already mentioned should be secured.

The amount of lime and sulphur required was determined by actual titration with known mixtures of milk of lime and a 3 per cent  $H_2SO_3$  solution. The quantity of lime required to raise the pH of the settlings to 8.8 pH is a variable because of the variations in the pH of the settlings as discharged from the settling tanks. In this titration the pH of the original settlings was 6.5, which is abnormally low. The amount of lime required under these particular conditions was 1.05 pounds per ton of settlings; the lime is calculated as CaO. Titrations made in which the sulphur dioxide gas is used as the acidifying reagent, will be fairly regular, that is, the shape of the titration curve will be practically the same in all cases because the buffer action of the  $P_2O_5$  is almost completely removed. It was found that .43 pound of sulphur would be required per ton of settlings. Liming back the sulphured settlings to 7.4 pH requires between .2 and .3 pound per ton of settlings.

Sulphur costs about \$40 per ton or 2¢ per pound. Lime costs about \$15 per ton or 3/4¢ per pound. Using these figures, the estimated cost of the sulphur treatment would be between 3 and 4 cents per ton of sugar. This allows only a 50 per cent recovery of sulphur dioxide gas from the sulphur burned.

In Table XVII, are comparative results typical of the untreated, limed, Borden treated and sulphur treated settlings:

TABLE XVII

Untreated		Limed		Borden Treated		Sulphur Treated	
Vol. of Filtrate c.c.	Thickness 1/8"	Vol. of Filtrate c.c.	Thickness 5/16"	Vol. of Filtrate c.c.	Thickness 1/2"	Vol. of Filtrate c.c.	Thickness 5/8"
250	1/8"	850	5/16"	1380	1/2"	1720	5/8"
550	1/8"	850	3/16"	1600	3/8"	2075	1/2"
450	....	700	....	975	....	1350	1/4"
480	1/8"	950	1/4"	1475	3/8"	1525	3/8"
....	....	750	3/16"	1650	3/8"	2200	1/2"
....	....	....	....	1340	1/4"	2400	9/16"
....	....	....	....	1600	3/8"	2650	5/8"
500	1/8"	1000	1/4"	1350	5/16"	....	....
450	1/8"	950	1/4"	1100	5/16"	....	....
400	3/16"	940	1/4"	1280	5/16"	....	....
Average	440	1/8"	874	1/4"	1375	3/8"	1990
							9/16"

These data show the pronounced improvement in the filtrability of the settlings produced by the Borden treatment and the sulphur treatment. The filtrate from the untreated settlings and the limed settlings is invariably turbid. The cake is thin and sticky, that is, the cake sticks to the cloth.

The filtrate from the Borden treated settlings and sulphur treated settlings is clear and is usually a lighter color than the filtrate from untreated settlings. The cake is firm and leaves the cloth free. As a rule, the small tests indicate that the cake from sulphur treated settlings leaves the cloth freer and cleaner than the cake from Borden treated settlings. Compared to the filtrability of the untreated settlings liming alone increases the filtrability about 100 per cent, the Borden treatment about 200 per cent and the sulphur treatment about 300 per cent.

In view of the fact that liming settlings to about 8.5-8.8 pH increases the filtrability about 100 per cent, a few tests were made in which the lime was increased beyond these pH limits and filtration tests made. These results are given below:

TABLE XVIII

Treatment	pH	Vol. of Filtrate
Settlings limed to.....	8.5	700 c.c.
Settlings limed to.....	9.6	1100 c.c.
Settlings limed to.....	10.0+	1150 c.c.
Settlings limed to (large excess).....	...	1350 c.c.
Borden treated settlings.....	6.8	1340 c.c.
Sulphur treated settlings.....	7.3	2400 c.c.

The settlings limed above 8.5 pH showed an improvement in filtrability, but the cake formed in these tests was very sticky. Where a large excess of lime

was used, the filtrability is equivalent to that secured by the Borden treated settlings. The results secured by the sulphur treatment are almost 80 per cent better than the best results secured by liming. The objections to the heavy liming of settlings did not warrant any further tests.

A few filtration tests were made in which varying amounts of Hyflo-supercel were added to limed settlings. The results have been tabulated below:

TABLE XIX

Treatment	Gms. H.S.* Per 10 Liters	Lbs. H.S.* Per Ton Cane	Vol. of Filtrate	Thickness of Cake
Settlings limed to 8.6 pH.....	.....	.....	950 c.c.	5/16"
Settlings limed to 8.6 pH.....	10 grams	.5 lb.	1080 c.c.	3/8"
Settlings limed to 8.6 pH.....	20 grams	1.0 lb.	1100 c.c.	3/8"
Settlings limed to 8.6 pH.....	35 grams	1.75 lbs.	1200 c.c.	7/16"
Borden treated settlings.....	.....	.....	1550 c.c.	9/16"
Sulphur treated settlings.....	.....	.....	2900 c.c.	1 1/8"

No difference in the appearance of the cake could be observed in these tests with Hyflo-supercel. The increase in filtrability is small, which would mean that large amounts would have to be added. The cost of such a filter aid would be prohibitive, so that no further tests were made.

*Strained Settlings:*

A group of experiments were made on settlings which were passed through an 80-mesh screen to remove the cushion. The filtrability of these strained settlings was compared when subjected to the various treatments. The results appear in Table XX:

TABLE XX

Treatment	Test I	Test II	Test III
	Vol. of Filtrate	Vol. of Filtrate	Vol. of Filtrate
Untreated settlings .....	300 c.e.	325 c.e.	450 c.e.
Limed settlings .....	650 c.e.	675 c.e.	700 c.e.
Borden treated settlings.....	975 c.e.	.....	975 c.e.
Sulphur treated settlings.....	1425 c.e.	1650 c.e.	1350 c.e.

There is a reduction in the volume of filtrate in all the tests on strained settlings, yet the proportional differences for the various treatments remain practically the same. The cake formed in these tests shows about the same characteristics as that formed with unstrained settlings, with the exception that in the Borden treated and sulphur treated settlings a cake is formed which is more coherent and can be discharged from the cloth quite readily.

\* H.S. abbreviation for Hyflo-supercel.

The reduction in the volume of filtrate when strained settling<sup>s</sup> are filtered amounts to about 25-40 per cent. During the year Peck strained settling<sup>s</sup> were filtered by the Oliver Filter at several different times. Under these conditions the capacity of the filter was reduced by about 25 per cent. The cake on the Oliver seemed to take the wash water. The press station could not handle the Peck strained settling<sup>s</sup> when the mill was operating at full capacity so that the Oliver could be run only a few hours at a time, which is not long enough to fully test the filter on these settling<sup>s</sup>.

## PART II THE OLIVER FILTER

### *Description of the Oliver Filter:*

The Oliver Filter, which was installed at the Oahu Sugar Company this past year, is known as a drum type rotary filter. The filter consists of a drum 8 feet in diameter and 12 feet in length, having a filtering area of 300 square feet. This drum rotates on a horizontal axis with the lower portion submerged in a tank containing the settling<sup>s</sup>. The tank is large enough so that 55 per cent of the surface of the drum can be submerged.

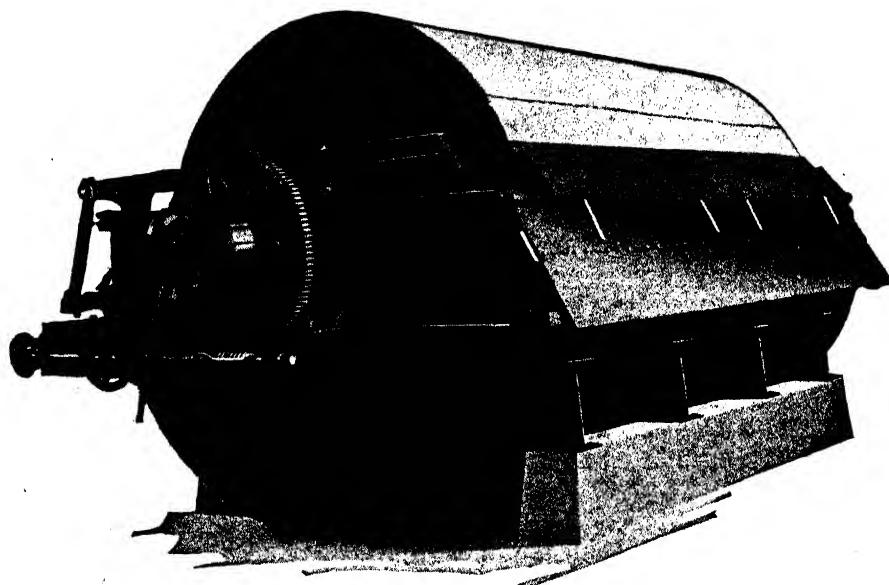


Fig. 1. The Oliver Filter. (Illustration by Oliver Continuous Filter Company.)

The surface of the drum is divided into 24 sections or compartments, the partitions between sections being parallel to the horizontal axis. The dimensions of these sections are 1 foot wide by 12 feet long by 1 inch deep, having a volume of one cubic foot. A perforated screen covers each compartment and supports the filter cloth. The filter cloth covering the drum is held in place by wire winding spaced about one inch apart. Each section is connected by pipes passing through a hollow trunnion to an automatic valve which controls the application of the

vacuum for forming and washing the cake and also for the admission of steam used to discharge the cake. Thus each compartment forms an independent unit, although the filter cloth is attached as a continuous cover over the whole surface of the drum.

An agitator is placed in the bottom of the tank which prevents any separation of the heavier particles, thus insuring an uniform mixture which is necessary to secure an even cake.

A scraper is attached across the tank and rests on the wire winding in such a manner that as the steam blow is admitted to the section, the cloth bulges slightly between the wire winding, lifting the cake which allows the scraper to discharge it. The success of the filter depends entirely on the ease with which the cake leaves the cloth.

Five rows of spray nozzles and one drip pipe are mounted over the top portion of the drum for applying the wash water. As the drum rotates the filtering surface is passed through the settling in the tank. Immediately, as each compartment under vacuum is immersed, a cake begins to form and continues to form to the point of emergence from the tank. The liquid or filtrate passes through the vacuum pipes to the automatic valve and receiver. The cake is allowed to dry out before the first row of spray nozzles is reached. The amount of wash water to be applied depends upon the thickness of the cake. The time elapsed after the cake emerges from the settling and when the first wash water is added depends on the character of the cake. After the cake passes under the five rows of spray nozzles and the drip pipe a very thorough washing is secured.

As each section passes out of the washing zone, the vacuum is automatically cut off and the steam blow admitted as this section passes under the scraper which discharges the cake. This leaves a clean surface which passes to immersion and a new cycle. (See Figs. 1 and 2.)

The automatic valve which controls the vacuum is so constructed that the cake is formed at a certain degree of vacuum and is washed at a higher vacuum.

#### *Time of Cycle:*

An eight-minute cycle was found to give the best results for all conditions. Thickness of cake, washing time, peripheral speed, and flexibility are the important factors to be considered in deciding upon the optimum time of the cycle.

As the most desirable thickness of cake is  $\frac{3}{4}$ " to  $\frac{3}{8}$ ", with good filtering settling a shorter time cycle might be used, but with poor filtering settling, more time is required to form a cake of the desired thickness. There is quite a large variation in the filtering characteristics of settling.

The washing time is perhaps the most important factor which controls the time of the cycle. The principal object of the Oliver Filter is to recover more sucrose from the cake than is ordinarily recovered in the plate and frame presses. In order to do this, about 200 per cent water on the weight of cake must be applied through the system of spray nozzles. Here again we have the variations in cake to consider. In some types of cake the water can be applied within 25 or 35 seconds after it emerges from the settling. In other types of cake, a longer

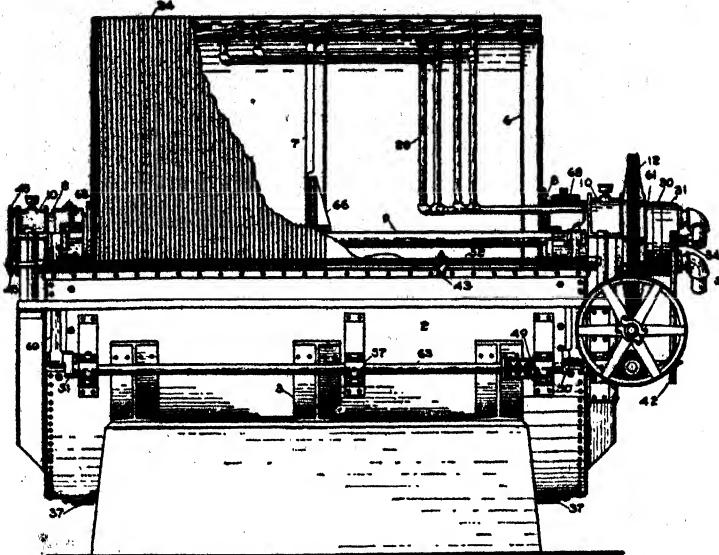


Fig. 2. Showing the essential parts of the Oliver Filter:  
 1a, Closed steel drum head; 2, Steel filter tank; 3, Tank feet;  
 6, Drum rims; 7, Drum arms; 8, Drive trunnion; 8a, Rear trunnion;  
 10, Main bearing (drive end); 10a, Main bearing (rear end);  
 12, Worm wheel; 18a, Bevel pinion; 24, Wire winding;  
 28, Vacuum and air pipes; 30, Renewable valve seat; 31, Auto-  
 matic valve; 32, Vacuum connections; 34, Valve stem; 42, Valve  
 adjusting rod; 42a, Valve adjusting bracket; 43, Wiring car-  
 riage; 45, Wiring sprocket; 45a, Feed screw sprocket; 46, Wir-  
 ing feed screw; 51, Agitator crank; 56, Spur gear; 56a, Ratchet  
 spur gear; 56b, Spur gear flange; 57a, Crankshaft bearing; 61,  
 Valve pipe plate; 62, Drum manhole; 63, Crankshaft; 66, Center  
 spider; 69, Connecting rod; 75, Feed connection; 76, Drain con-  
 nection; 78, Pinion shaft; 79, Wiring carriage guide; 83, Auto-  
 matic valve nipple; 85, Agitator crank pin; 88, Stave hook bolt;  
 89, Ratchet lever. (Illustration by Oliver Continuous Filter  
 Company.)

time must be allowed before applying the wash water. If the wash water is applied too soon the water will cut grooves in the cake; this will result in decreased capacity of the filter, inefficient use of the wash water and a quicker fouling of the cloth. The cake when it first emerges from the tank is very delicate. It must be allowed to dry out before the first row of spray nozzles is reached. The first wash water should be applied before the cake starts to crack. Enough wash water must be applied so that when the cake is discharged, the cloth itself will appear to be wet. The writer believes that when this condition prevails the cloth will remain cleaner for a longer time. Under actual operating conditions, between 5 and 8 gallons of water are applied per minute.

#### Type of Tank:

The Oliver Filter is equipped with a tank of such a size that 55 per cent of the surface of the drum can be submerged in settlings. For filtering cane settlings the writer believes that a tank of this depth will prove to be the most satisfactory. With the daily and seasonal variations in the characteristics of cane settlings, sufficient leeway must be allowed to take care of all such fluctuating con-

ditions. A tank in which the drum is only 40 per cent submerged could be used at times when settling characteristics are available. With settling low in the per cent suspended solids and settling requiring a longer filtering (pick up) cycle, such a tank would prove inadequate. While there is a difference of about \$1,000 in the price of the filter with this shallow tank, the writer believes that such a tank would not meet all the conditions encountered during a grinding season. The tank now in use has a total capacity of 160 cubic feet of settling. This represents about three-fourths of an hour's supply of settling. If the capacity of the tank can be reduced without changing the per cent of submergence, it would be an advantage.

#### *Blow:*

A steam blow is used to loosen and lift the cake as it is discharged from the cloth by the scraper. The blow is admitted into a section as it reaches the scraper and into two sections following the scraper. The pressure of the blow is between 40 and 50 pounds gauge. The main objection to steam blow is that it is hard on the cloth. Certain changes are planned which will tend to lessen this effect.

Both cold air and hot air blow were tried but the results secured were not as satisfactory as the steam. The cloth does not remain clean as long as it does with the steam blow. Mixtures of air and steam were tried without any beneficial results.

#### *Vacuum:*

According to tests made on the small test leaf, the cake should be formed at low vacuums. As the vacuum under which the cake is formed is lowered the cake leaves the cloth much freer. With the Oliver Filter in good mechanical condition this seemed to hold true. Of course there is the variation in the character of the settling to be considered. Actually no definite vacuum can be maintained for all settling. The important point is that as low a vacuum should always be maintained as will give a cake of the most desirable thickness. In actual operation the vacuum varies from two inches to fifteen inches, depending on the nature of the settling. If too high a vacuum is carried when the cake is being formed the solid material is drawn into the cloth, making it difficult to wash and discharge.

Usually a higher vacuum is used when the cake is being washed. Although this is not always the case, the vacuum applied to the washing cycle is about 5 inches greater than the vacuum on the pick-up cycle. When high vacuums are maintained on the filtering cycle, then there is only a small difference between the vacuums.

#### *Filter Cloth:*

Two types of cloth, plain weave and twill weave, were used on the Oliver Filter. The plain weave or 10 oz. duck was used at a time when the filter was not in good mechanical condition. It was thought that this cloth, because of its

relatively smooth surface, would allow the cake to loosen and leave it free. The cloth did not have the mechanical strength to withstand the force of the steam blow. Heavier weights in this cloth would undoubtedly prove too closely woven for the purpose.

A 15 oz. twill, designated by the manufacturer as 1530 Hooperwood Twill, was used during all but one week of the two months continuous run of the Oliver Filter. This cloth is a more open weave than the duck. One cover made of this cloth was in use about five weeks altogether. A second cover of the same cloth was in use three weeks. At the end of this time, it had to be replaced. Under average conditions, a cover made of this cloth will last about four weeks.

The 18 oz. twill, which was used during the last week of run, was in the writer's opinion too heavy for this work. The heavier weight would give the cloth greater mechanical strength, but it seemed to the writer that the cloth became dirty quicker and required more frequent scrubbing than the 15 oz. twill. The settling handled during this week contained more soil than ordinarily, due to the rainy weather, but the lighter weight twill was used for a few days on the same type of settling without giving any trouble. In the writer's opinion the lighter cloth will prove more satisfactory under all conditions.

#### *Washing the Oliver Filter Cloth:*

The Oliver Filter cloth should be scrubbed every eight hours. During the past year the filter ran for 22 hours at a time without scrubbing, but as a rule, it was washed every twelve hours. It is the opinion of Mr. Borden, of the Oliver Continuous Filter Company, that more frequent scrubbing will result in increased capacity and will facilitate the washing of the cake materially. With a factory fully equipped with Olivers, a constant total filtering surface could be in operation at all times, that is, as one filter is cut out to wash the cloth, a clean one can be cut in. It has been estimated that six filters would handle the settling at the Oahu Sugar Company under all conditions and that four filters would filter the settling during the greater part of the time.

Some attempts were made during the year to devise a method of cleaning the cloth without draining the settling in the tank back into the mud tanks. But so far these have been unsuccessful. The method of washing the cloth follows:

The settling remaining in the tank are drained into the mud tank. This drain valve is then closed and the drain to the sewer is opened. Both vacuum lines are closed tight so that there is no vacuum in any of the sections. A hot water wash line is turned on, removing any surplus cake. When the cake is removed a gang of men scrub the cloth with fibre brushes. Compressed air is admitted into the sections. This seems to loosen and dislodge small particles which accumulate in the cloth. After the cloth is thoroughly scrubbed, a weak acid solution is applied to the cloth. This removes any material which remains in the cloth. The acid treatment need only be applied once a day. The cover is then washed with hot water until the washings show no trace of acid. They can be tested with an indicator. All these washings are run into the sewer.



TABLE XXI

	3 days ending April 24, 1926	Week ending May 1, 1926	Week ending May 8, 1926	Week ending May 15, 1926	Week ending May 22, 1926	5 days ending May 29, 1926	Week ending June 5, 1926	Week ending June 12, 1926	Week ending June 19, 1926	Period April 22, to June 19, inclusive
1 Tons cane .....	9586.	15798.	16828.	17858.	17509.	15120.	16328.	14491.	16008.	142570.
2 Tons sugar .....	1295.	2511.	2227.	2314.	2320.	2045.	2227.	1953.	2114.	19000.
3 Per cent $P_2O_5$ in Crusher Juice.....	.017	.018	.026	.022	.023	.028	.020	.016	.026	.022
4 Tons settling per day.....	.064.	.616.	.679.	.695.	.743.8	.767.1	.620.	.518.	.643.	.658.
5 Settling % Mixed Juice.....	18.5	17.0	20.8	20.6	22.8	22.2	20.5	20.15	21.77	20.55
6 Tons cane per ton of settling.....	4.81	5.09	4.13	4.28	4.10	3.94	4.39	4.65	4.16	4.33
7 Tons settling filtered by Oliver per day.....	158.7	168.4	178.	175.6	153.0	174.9	154.2	144.5	149.3	161.8
8 Tons settling filtered by Oliver per hour....	7.21	7.06	8.10	7.98	7.39	7.95	7.21	7.05	7.25	7.52
9 Tons settling filtered by Oliver per week...	476.0	1010.4	1068.	1053.0	918.0	874.5	925.2	867.0	895.8	970.6
10 Tons cane equivalent to tons settling filtered by Oliver per hour .....	34.5	30.0	33.45	34.15	30.3	31.3	31.65	32.85	30.16	32.56
10a filtered by Oliver per day.....	763.35	859.0	736.	751.	627.2	689.0	677.3	673.4	621.3	700.0
11 Hour filtering per day .....	22.	22.	22.	22.	20.7	22.	21.4	20.5	20.6	21.5
12 Hour filtering per week .....	66.	132.	132.	122.	124.	100.5	128.5	123.	123.0	129.0
13 Gallons settling per sq. ft. per hour.....	5.50	5.88	6.20	6.10	5.7	6.1	5.53	5.41	5.56	5.79
14 Settling filtered by Oliver % total settling.....	23.9	27.4	20.2	25.25	21.5	22.8	25.0	27.0	23.2	24.8
15 Suspended solids % settling (calculated)...	2.5	2.9	2.05	2.27	2.06	1.90	2.0	2.4	2.25	2.28
16 Thickness of cake (calculated).....	1/4"	5/10"	1/4"	1/4"	3/10"	3/16"	5/32"	5/32"	7/32"	7/32"
17 Tons cake from Oliver per hour (calculated).....	1.20	1.42	1.15	1.20	0.98	0.98	0.91	0.80	1.08	1.086
18 Tons cake from Oliver per day (calculated)...	26.5	31.2	25.4	26.5	20.2	21.4	19.5	18.5	22.16	23.35
19 Tons cake from Oliver per week (calculated).....	79.2	187.4	152.4	159.0	121.2	107.0	117.0	111.0	133.0	140.1
20 Tons cake from Oliver equivalent to ton of press cake from old presses.....	1.47	1.50	1.50	1.66	1.52	1.39	1.38	0.77	1.27	1.40
21 Polarization % cake from Oliver.....	0.97	1.31	1.25	1.02	1.17	0.94	1.18	1.25	1.12	1.14
22 Moisture % cake from Oliver.....	82.7	83.4	84.29	84.8	82.74	83.4	83.3	81.47	81.5	83.29
23 Tons polarization in Oliver cake per week..	0.77	2.45	1.91	1.62	1.42	0.90	1.38	1.30	1.49	1.566
24 Polarization % press cake from old presses.....	4.4	4.53	4.16	3.50	4.58	5.61	4.87	5.43	5.14	4.69
25 Moisture % press cake from old presses.....	71.6	71.9	74.6	72.00	71.8	72.2	73.63	76.83	75.28	73.31
26 Tons press cake equivalent to tons cake from Oliver per week .....	54.0	124.5	101.4	96.0	79.5	77.0	85.0	114.0	105.0	97.8
27 Tons polarization in press cake.....	2.88	5.64	4.22	3.36	3.63	4.32	4.14	6.19	5.4	4.59
28 Tons polarization saved by Oliver per week.....	1.61	3.19	2.31	1.74	2.22	3.59	2.76	4.80	3.01	2.99
29 Estimated saving of total tons polarization by Oliver on all settling per week.....	0.74	11.64	8.92	6.89	10.33	11.80	11.04	17.21	16.85	12.06
30 Tons polarization available per week.....	0.20	10.71	8.11	0.34	9.50	10.86	10.16	15.83	15.50	11.10
31 Pol. in cake from Oliver per 100 cane.....	0.634	.048	.043	.030	.028	.020	.034	.034	.040	.0375
32 Pol. in cake from presses per 100 cane.....	.104	0.11	.066	.075	.097	.125	.101	.153	.145	.108
33 Tons double superphosphate per week for settling filtered by Oliver.....	1.06	2.25	2.00	2.00	1.69	1.81	1.94	2.31	2.125	2.06
34 Tons settling per ton of double superphos.	449.	449.	534.	527.	543.	483.0	477.	375.	421.	470.5
35 Tons double superphosphate per week for all the settling .....	4.44	8.21	7.63	7.92	7.86	7.04	7.76	8.28	9.70	8.31
36 Total cost of double superphosphate per week at \$56.80 per ton.....	\$ 252.19	496.33	433.38	449.86	446.45	450.00	440.77	470.33	550.96	472.00
37 Cost of double superphosphate per ton of sugar \$	0.195	0.179	0.195	0.194	0.102	.22	0.198	0.241	0.26	.208

*Operating Data of the Oliver Filter:*

The Oliver Filter was put into regular operation on April 22 and ran continuously until the end of the crop, June 22, 1926, stopping only for washing the cloth or when the mill was shut down. Previous to this time considerable difficulty was experienced due to a mechanical defect in the filter itself and to the mechanical handling of the settling. All the settling which were filtered by the Oliver Filter were treated in a small mixing tank divided into two compartments, each having a volume of 40 cubic feet. The lime and double superphosphate were added and gently stirred with a paddle, by hand. The treated settling were run into the Oliver Filter by gravity. A count of the tanks was kept so that the volume of settling filtered each day was known.

Table XXI, which follows, gives the operating results for each week and for the period.

*Discussion of the Operating Data Given in the Above Tabulation:*

Item 3. Per Cent  $P_2O_5$  in Crusher Juice: The variations in the phosphoric acid content of the crusher juice are relatively small. However, for conditions which prevail at the Oahu Sugar Company, Ltd., they are normal, that is, none of their juices are very high in  $P_2O_5$  so that these variations are as large as might be expected at any time. The relation between the settling per cent mixed juice and the  $P_2O_5$  in crusher juice is fairly consistent. As the  $P_2O_5$  increases, the volume of the settling increases. This would be more pronounced if the liming of the mixed juice were constant, but the pH of the limed mixed juice was reduced in the "so-called" high phosphate juices. This reduced the volume of the settling.

Item 4. Tons Settling per Day: From the number of mud tanks filled each day, the tons settling were calculated. This figure is necessary in order to accurately estimate the number of filters required to meet all the conditions encountered during the year.

Item 5. Settling Per Cent Mixed Juice: Tons settling per day divided by tons mixed juice per day gives settling per cent mixed juice. While the average figures for the weeks do not show a wide variation in the settling per cent mixed juice, daily figures show a wider variation. The minimum figure per day during this period is 16.2 per cent and the maximum is 28.3 per cent settling.

Item 6. Tons Cane per Ton of Settling: Dividing the tons cane per day by the tons settling gives the tons cane per ton settling. There is a fairly consistent relation between the tons cane per ton of settling and the  $P_2O_5$  in crusher juice. As the  $P_2O_5$  in crusher juice increased, the tons cane per ton of settling decreased.

Item 7. Tons Settling Filtered by the Oliver Filter per Day: The settling filtered by the Oliver Filter were measured. From this, the tons settling were calculated. The average daily capacity of the Oliver Filter for the first seven weeks is fairly constant. Due to irregular grinding during the last two weeks this figure is somewhat lower.

Item 8. Tons Settlings Filtered by the Oliver per Hour: Dividing the tons settlings filtered per day by the hours actual filtering time gives the tons settlings filtered per hour. The actual filtering time is used in this calculation rather than the total operating time, which would include the time required for washing the filter. If a factory is completely equipped with Oliver Filters, when one filter is shut down to be washed a clean filter is put into service without any reduction in the total filtering surface in use.

These figures show that the capacity of the Oliver is fairly constant, there being only one ton difference between the maximum and minimum tons settlings filtered by the Oliver per hour.

Item 10. Tons Cane Equivalent to Tons Settlings Filtered by the Oliver per Hour and per Day: The average for the period shows that the Oliver filtered the settlings from 32.56 tons cane per hour or 700 tons cane per day.

Item 11. Hours Filtering per Day: For the first four weeks, this is estimated at 22 hours per day. For the remainder of the period, the actual filtering time was recorded.

Item 13. Gallons of Settlings per Square Foot per Hour: This figure is given simply for comparative purposes. The average figures for the individual weeks are fairly constant.

Item 14. Settlings Filtered by the Oliver Per Cent Total Settlings: From items 7 and 8 it is seen that the capacity of the Oliver Filter is fairly constant. With variations in the grinding rate and variations in the volume of settlings per cent mixed juice, it is quite natural to expect large variations in item 14. However, it indicates the number of filters which would be required to meet all the varying conditions. The figures given may be too low by a few per cent; nevertheless, they are comparative. The settlings filtered by the Oliver Filter are accurately measured, while the settlings filtered in the presses are calculated from the number of mud tanks filled each day. It is possible that at times these tanks were not entirely emptied because of lack of tank capacity. On the other hand, we assumed that the tanks were filled always to within six inches of the top allowing 325 cubic feet of mud per tank with an actual capacity of 350 cubic feet. For this reason, the writer did not make any corrections in the volume of settlings filtered in the presses.

Item 15. Suspended Solids Per Cent Settlings: This figure was calculated from the cake solids and the volume of settlings filtered. Although the weekly averages are fairly uniform there is considerable fluctuation during the day. The suspended solids in the settlings have been as high as 5.0-6.0 per cent.

Item 16. Thickness of Cake: The average thickness of cake for the Oliver Filter was calculated from the weight of cake per hour, the average for the run being  $7/32''$ . To secure the best results the cake should be at least  $3/16''$  and not greater than  $3/8''$ . When the cake is too thin, it becomes less coherent with the result that when it is discharged, it will not leave the cloth clean. If the cake is too thick, the amount of wash water which must be applied to reduce the polarization of the cake to less than 1.0 per cent cannot be added in the time available.

Item 17. Tons Cake from the Oliver per Hour: With the exception of one week, the cake discharged from the Oliver Filter per hour is fairly uniform. The average for the run was 1.09 tons per hour; this is equivalent to 0.78 ton press cake per hour.

Item 20. Tons Cake from the Oliver Filter Equivalent to Cake from Presses: Due to the difference in moisture content and polarization, 1.40 tons of Oliver cake is equivalent to 1.0 ton cake from presses. With the exception of one week this ratio is fairly uniform. This factor must be applied to the polarization and the weight of cake from the Oliver Filter, to reduce these figures to an equivalent basis with the filter press data.

Item 21. Polarization Per Cent Cake from Oliver: The average for the run was 1.14. With more experience in the operation of the filter and the application of the wash water, it is possible to reduce this polarization materially. There were a few times when it seemed impossible to reduce the polarization of the cake to a lower figure. With a constant pressure on the wash water line and with wash water free from cushion-cushion particles which clogged the nozzles, the washing of the cake should be facilitated. A polarization of 1.14 per cent on Oliver cake is equivalent to 1.6 per cent polarization on filter press cake.

Item 22. Moisture Per Cent Cake: The per cent moisture in cake cannot be reduced below this point. As the cake dries out, a point is reached where the cake begins to crack; further drying out is impossible. Due to the varying composition of the cake, the per cent moisture will vary a few per cent as is indicated by the weekly averages.

Item 34. Tons Settlings per Ton of Double Superphosphate: This figure is the actual amount of settlings treated at the Oliver Filter per ton of double superphosphate. Two tests which were made by Mr. Borden and the writer, indicate that the tons settlings per ton of double superphosphate can be materially increased. In one test, 1,360 cubic feet of settlings were treated with one bag of double superphosphate; in the second test 1,120 cubic feet were treated with one bag of acid. The average of these two tests is 1,240 cubic feet per bag of double superphosphate or 41.3 tons settlings per bag of double superphosphate. This amounts to 660 tons settlings per ton of double superphosphate. With more experience, the operator should be able to approach this figure.

Item 37. The Cost of Double Superphosphate per Ton of Sugar: The average for the period is 20.8 cents per ton of sugar. The weekly figures vary considerably. On the basis of data mentioned above, the cost of the double superphosphate is .15 cents per ton of sugar.

#### *Statement of Estimated Savings and Costs:*

In estimating the total saving which might be secured by filtering all the settlings with Oliver Filters, it has been assumed that six Olivers having a filtering surface of 300 square feet each, would be required. Five filters would handle all the settlings during the greater part of the time. However, at certain times, such as the first six weeks of the crop, six filters would be required. The

settlings which were secured at this time of the year did not respond to the Borden treatment to the same extent that they did later in the year.

A comparative statement of operating costs of the Oliver Filter and the filter presses, also the estimated savings due to the Oliver Filters has been itemized in the following tabulation:

	Oliver Filter	Filter Presses
Double superphosphate, per ton of sugar.....	20.8 cents	10.0 cents
Labor, per ton of sugar.....	3.5 cents	5.6 cents
Filter cloth, per ton of sugar.....	0.8 cents	7.5 cents
Acid for cleaning cloth, per ton of sugar.....	0.3 cents	.....
Oliver wire, per ton of sugar.....	0.3 cents	.....
 Total operating expenses, per ton of sugar.....	 25.7 cents	 23.1 cents
 Value of sugar lost in cake, per ton of sugar.....	 19.7 cents	 57.0 cents
 Total cost, per ton of sugar.....	 45.4 cents	 80.1 cents
 Less the fertilizer value of the double superphosphate recovered in the press cake, per ton of sugar.....	 19.1 cents	 9.2 cents
 Net cost, per ton of sugar.....	 26.3 cents	 70.9 cents
 Estimated saving made by Oliver Filters, per ton of sugar .....	 44.6 cents	

For a crop of 62,500 tons of sugar—\$27,875.00.

The above statement applies to conditions which prevail at the Oahu Sugar Company, Ltd.

In the above tabulation, the cost of treating the settlings filtered by the filter presses is 10 cents per ton of sugar, while the cost of treating the settlings filtered by the Oliver filter is 20.8 cents. There are two reasons for this difference in cost. One is that the treatment given the settlings filtered by the presses was purposely reduced, that is, the settlings were limed to a lower pH than the Borden treatment requires. The full benefits of the Borden treatment will not be secured, however, under these conditions. The second reason is that the settlings filtered by the Oliver Filter were overlimed before the addition of the double superphosphate. This, naturally, requires more of this reagent. With a more careful and experienced operator, the quantity of the double superphosphate should be reduced with a material reduction in cost.

It seems to be legitimate to include the cost of the double superphosphate used in treating the settlings filtered by the filter presses as an operating expense for several reasons. The average grinding rate for the 1926 crop was 2,820 tons of cane per day. For 1925 crop it was 2,490 tons of cane per day. For the 1925 crop there were 12 presses with a total of 8,000 square feet of filtering surface available. For five months of the 1926 crop, there were only 10 presses with a total of 6,700 square feet filtering surface available, with the addition of

the Oliver Filter during the last two months. It is very unlikely that the higher grinding rate could have been maintained without treating the settlings. So that any savings which result with the increased grinding rate should be credited to the treatment of the settlings.

The benefits which were secured by treating the settlings are as follows:

First, there was an improvement in the filtrability of the settlings resulting in a shorter filling cycle of the presses. For the 1925 crop, each press discharged an average of 4 tons of cake per day; for the first 5 months of the 1926 crop each press discharged 6.6 tons per day, an increase of over 50 per cent.

Second, the filtrate or filter press juice was sent directly to the evaporator supply tank. This reduced the load on the settling tanks by 20 per cent, because in former years the filter press juice was returned to the mixed juice. This is generally the practice where the settlings are limed heavily before filtration. By reducing the load on the settling tanks, ample settling time was available with this increased grinding rate so that the mixed juice could be limed to its optimum reaction during the greater part of the time.

If the capacities of the settling tanks and filter presses were such that the settlings could be filtered without treatment, regardless of the grinding rate then the treatment would be unnecessary.

#### *Filter Cloths:*

The estimated cost of filter cloth for six Olivers for a whole crop was calculated in the following manner: One filter was operated for two months with the cost of filter cloth amounting to \$40. During this time, this filter averaged 24.8 per cent of the total settlings. All the settlings could have been filtered with cloth costing \$161.30. Nineteen thousand and six tons of sugar were manufactured during this period, so that the cost per ton of sugar is 0.8 cent. The average cost of filter cloth for the filter presses has been estimated at 7.5 cents per ton of sugar. The writer believes that this is a conservative estimate representative of Hawaiian practice. On such a basis, an installation of Oliver Filters would effect a saving of 6.8 cents per ton of sugar.

With the filter in continuous operation one cover was used for five weeks, the second cover was used for three weeks, or an average of four weeks per cover. With a battery of six Oliver Filters, where each filter would be operating only a part of the time, one cover would last for over five weeks. In making this calculation, it is assumed that the only wear on the cloth is while the filter is in actual operation. The life of a cover will probably be lengthened by making some mechanical improvements which will protect the cloth from the steam.

#### *Labor:*

It has been assumed that the labor requirements per shift to operate six Oliver Filters would be as follows: one man to treat the settlings, two men to operate the filters and one man to wash the filters. With the wage scale which prevails at the Oahu Sugar Company, Ltd., this would amount to 3.5 cents per ton of

sugar. The labor cost to operate the filter presses is estimated at 5.6 cents per ton of sugar. Using a battery of Oliver Filters would effect an estimated saving of 2.4 cents per ton of sugar.

#### *Acid Used for Cleaning the Oliver Filter Cloth:*

A weak solution of muriatic acid is used to clean the Oliver Filter cloth once a day (24 hours). This amounts to about 1.5 gallons of acid per day per filter. On such a basis, approximately 50 carboys (120 pounds each) would be required. The cost per carboy is \$3.25 or \$162.50 per crop. This is equivalent to 0.26 cent per ton of sugar.

#### *Oliver Wire:*

Using No. 14 hard galvanized wire of .08" diameter, with 1" spacing on the drum, the covering of one Oliver Filter will require 3,900 feet, or 26 coverings will require about 102,000 feet, or 1,760 pounds. Stocking six reels of 20,000 feet each at \$29.65 per reel amounts to \$178 per crop. This is equivalent to 0.3 cent per ton of sugar. These figures have been taken from Mr. Borden's report (page 29).

#### *Value of Sugar Lost:*

Under the existing conditions at the Oahu Sugar Company, where the grinding rate has been greatly increased without a proportionate increase in the filter press station, it has been possible to effect a large saving in the polarization in the press cake. As shown in the tabulation the value of the sugar lost in the presses is 57 cents per ton of sugar, while that lost in the Oliver Filter is only 19.7 cents per ton of sugar, amounting to 37.3 cents per ton of sugar. It was assumed that 92 per cent of the sucrose lost in the cake was available. The market value was calculated as 97.5 per cent sucrose, at \$82.40 per ton less 10 per cent.

#### *Fertilizer Value of Double Superphosphate Recovered in the Press Cake:*

When the Borden treatment of the settlings is carefully controlled, then we can expect to recover all the double superphosphate in the press cake. This will be in the form of a calcium phosphate salt, but in a very finely divided condition. The cake from the Oliver Filter contains about .5-.6 per cent more P<sub>2</sub>O<sub>5</sub> than ordinary press cake. The availability of the phosphate has been tested on four samples of cake submitted to the chemistry department for analysis. The following tabulation gives the results of their analyses:

	P <sub>2</sub> O <sub>5</sub> Per Cent Cake		
	Total	Available	Per Cent Available
Cake from treated settlings.....	0.958	0.890	92.90
Cake from treated settlings.....	0.940	0.860	91.50
Cake from treated settlings.....	1.276	1.166	91.40
Cake from untreated settlings.....	0.475	0.415	87.40
Average cake from treated settlings	1.058	.972	91.9

From these analyses it is evident that the fertilizer value of the press cake will be increased by an amount equal to 91.9 per cent of the total cost of the double superphosphate.

The total cost of distributing and spreading the Oliver cake for a crop will be increased by about 40 per cent. This is due to the fact that 1.4 tons of Oliver cake is equivalent to 1 ton of press cake. This increase in cost of distributing and spreading the press cake should be charged against the fertilizer value of the press cake.

Whether the total cost of the double superphosphate should be charged against the Borden treatment depends largely on the particular conditions prevailing at a plantation. When the soil requires phosphate application, the phosphate in the press cake should prove just as effective as the phosphate in fertilizer. This is the opinion expressed by the agricultural department of this Station. Under such conditions, the writer believes that it is logical to allow the fertilizer value as calculated, less the increased cost of distribution.

The estimated saving made by the Oliver Filter per ton of sugar as explained in the discussion is 44.6 cents per ton of sugar. For a crop of 62,500 tons of sugar this amounts to \$27,875. If, on the contrary, we assume that the settling could have been filtered in the presses without any treatment and still maintain the same grinding rate and further, if the total cost of the double superphosphate is charged against the Borden treatment, this would reduce the estimated saving to 24.7 cents per ton of sugar, amounting to \$15,437.50 for a crop of 62,500 tons of sugar.

The power required to operate six Olivers is small, amounting to about 35-40 horsepower. This includes the power to run a vacuum pump of suitable capacity for an installation of this size. The steam used in discharging the cake is also negligible. These items are compensated for by a similar power requirement to operate the pumps which pump the settling and water into the presses at fairly high pressures. Using less wash water on the weight of cake will also result in a saving of fuel because there will be less dilution of the filtrate with the result that less water will have to be evaporated. Interest on the investment, depreciation, upkeep and repairs, cannot be accurately estimated for an installation of Oliver Filters. It is quite possible that they will be somewhat less than similar charges for a new installation of filter presses.

The preceding comparative statement of estimated costs and savings between the Oliver Filters and filter presses is based on the conditions which exist at the Oahu Sugar Company, Ltd. The high polarization in the press cake is due largely to a lack of filter press capacity. For a factory of this size there should be about 15,000 square feet of filtering surface available. This factory had only 6,700 square feet of filtering surface available in the filter presses this past year. During the two months of the Oliver run, slightly over 75 per cent of the settling were filtered by these ten presses.

If there were sufficient filter press capacity which would approximate Hawaiian standards, then it is reasonable to assume that the polarization of the press cake

could be reduced to 2.28 per cent. This is the average for all the factories for 1925. The moisture in cake is assumed to be 71.0 per cent. Using these figures in a similar statement as the preceding one, we then have as follows:

	Oliver Filters	Filter Presses
Total operating expense, per ton sugar.....	25.7 cents	13.1 cents
Value of sugar lost in cake, per ton sugar.....	19.7 cents	22.6 cents
<hr/>	<hr/>	<hr/>
Total cost, per ton sugar.....	45.4 cents	35.7 cents
Less the fertilizer value of the double superphosphate recovered in the press cake, per ton sugar.....	19.1 cents	.....
<hr/>	<hr/>	<hr/>
Net cost, per ton sugar.....	26.3 cents	35.7 cents
 Saving made by the Oliver Filters, per ton of sugar..	 9.4 cents	

This would amount to a saving of \$5,875 for a crop of 62,500 tons of sugar. If the process had to pay for the double superphosphate, then it would cost 9.7 cents more per ton of sugar to operate Oliver Filters than a battery of filter presses.

#### *Advantages of the Oliver Filter:*

A low polarization in Oliver cake can be secured.

The amount of wash water is between 200-250 per cent on the weight of cake, thus the dilution of the filtrate is small. The cake is formed on the filter, washed and discharged in an eight-minute cycle, eliminating inversion losses which frequently occur in plate and frame presses. Although the reaction of the settling is at 6.8 pH, the temperature is considerably reduced so that the inversion while the settling are in process about one hour, is practically negligible.

With the exception of washing the filter once every 8-12 hours no manual labor is required. The saving in labor cost has been estimated to be 40 per cent.

Using the Oliver Filters will reduce the filter cloth cost by about 90 per cent.

The filtrate is clear and sent directly to the evaporators. The purity of the filtrate is about 1.0 per cent less than the purity of the clarified juice.

#### *Disadvantages:*

The cost of the double superphosphate per ton of sugar is 20.8 cents. If the process must pay for this acid by recovering the sucrose in the cake, it can only do so when the polarization is abnormally high. Such a condition exists at Oahu Sugar Company, Ltd., but this is due to a lack of filter press capacity.

The successful operation of the Oliver Filter will require close supervision *all the time*. Carelessness in the treatment of the settling can result in a complete stopping of the filtration. The application of the wash water must be closely watched, otherwise harmful effects which will result in reduced capacity will be secured. Wash water free from suspended solids at a constant pressure will undoubtedly eliminate some of the troubles encountered this year, but with

varying thicknesses of cake such as frequently occur, careful supervision is essential.

A summary of filtering rates is tabulated below in which tons settling filtered per hour has been classified and averaged according to the suspended solids in the settling:

No. of Days Included in the Average	Average Per Cent Suspended Solids in Settling	Average Tons Settling Filtered Per Hour
10	1.5-1.9	7.73
25	2.0-2.4	7.60
9	2.5-2.9	7.43
4	3.0-3.9	7.43

These figures show that there is only a small difference in the quantity of settling filtered per hour with relatively large differences in per cent suspended solids. These data are presented here to show that the filtering capacity is not flexible. Where heavier liming is practiced on high phosphate juices resulting in a large increase in volume of settling, a larger number of Oliver's would have to be provided to meet such a condition. This point is cited not as a disadvantage but as one of the limitations of the filter. At times the capacity of the filter can be increased by increasing the vacuum and the time of submergence, but such a condition is very uncertain because it depends entirely on the character of the settling.

#### ACKNOWLEDGMENTS

The writer takes this opportunity to thank E. W. Greene, manager, F. J. Fleener, and H. W. Robbins, of the Oahu Sugar Company, Ltd., for their cooperation and for furnishing data which are contained in this report. The writer also wishes to thank John F. Borden, of the Oliver Continuous Filter Company, for the valuable information supplied by him.

## Influence of the Environment on Potato Mosaic Symptoms

A Review of a Paper by C. M. TOMPKINS\*

There are well authenticated instances of mosaic disease of sugar cane in these Islands, from which the symptoms of the disease have completely disappeared with age. Mosaic disease of sugar cane is analogous to mosaic disease of potatoes in many ways, so that the results with potatoes, reported in the above-cited paper, seem applicable to the instances of such disappearance of mosaic symptoms in sugar cane.

\* In *Phytopathology*, Vol. 16, No. 9, p. 581, September, 1926.

## HIGH ATMOSPHERIC TEMPERATURES MASK MOSAIC-DISEASE SYMPTOMS IN POTATOES

The author describes experiments in which mosaic-affected potato plants were placed in chambers at various temperatures. The symptoms of mosaic plants persisted when such plants were held at 59° F. or lower. On the other hand, similar plants exposed intermittently to temperatures of 75° F. or higher, lost the symptoms of mosaic disease completely. Mosaic-disease symptoms would reappear in these plants, if they were removed from the temperatures at 75° and replaced in the chambers at 59° F.

In other words, mosaic disease of potato plants became masked at temperatures of 75° or higher, but the symptoms recurred if the plants were removed again to a lower temperature.

The foregoing results were obtained by varying the temperatures of the air surrounding the plants. Raising the temperature of the soil was found to mask the symptoms of mosaic disease in potatoes in the early stages of growth of the plant, but did not have any effect on the symptoms of the disease on older plants.

## VARIATIONS IN HUMIDITY, LIGHT AND FERTILIZERS HAD NO EFFECT ON MOSAIC SYMPTOMS IN POTATOES

Variations in soil moisture, humidity and light failed to decrease or intensify the symptoms of mosaic in potato plants. Increases or deficiencies of nitrogen, phosphoric acid or potash, in pot studies also failed to decrease or intensify the symptoms of mosaic disease.

The foregoing results by Tompkins suggest that the apparent recoveries which we have noted in sugar cane, are in reality not recoveries, but merely a masking of the symptoms of the disease, which will probably recur in colder seasons.

Along somewhat similar lines of thought, we have at the present time rather complete field experiments to determine the effect of nitrogen, phosphoric acid, and potash on mosaic disease of sugar cane.

(H. A. L.)

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## The Use of Portable Electric Lights in Boilers\*

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Although entirely aware of the dangers of electricity at high voltages, nearly everyone has become so familiar with the usual 110 volt lighting circuits that little thought is ever given to the possibility of serious accidents from such circuits. Yet there are several cases on record in which shock from a 110 volt circuit has proved fatal. In the Syracuse Bulletin of May 14, 1926, there appeared an account of the death from electric shock of Ralph Merrill, a millwright at the Skaneateles Mill of the Oswego Falls Corporation. The man was working inside of a boiler preparing it for internal inspection, and was using a lamp and

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\* From *The Locomotive*, Vol. XXXVI, No. 4, pp. 110-111.

extension cord from a 110 volt circuit. In some way, probably through a faulty connection and contact with the brass socket, he received a shock that resulted in his death.

In the September, 1925, issue of *The Boiler Maker* appeared a brief account of the death from electric shock of Michael O'Brien, while he was cleaning a boiler in the Administration Building, Montclair, N. J. Faulty insulation on the wire of a lamp which he held in his hand while in contact with the boiler is said to have allowed the current to pass through his body, with fatal results.

About two years ago an inspector called at the plant of the Detroit Brass and Malleable Company, Detroit, to make an inspection. Upon inquiring for the engineer, a helper set out to find him. The inspector soon received a call to the top of one of the boilers, and there on top of the tubes inside of the boiler lay the engineer. He had been dead about a half hour. The charge from a 220 volt lamp on an extension cord which he had taken into the boiler with him had burned a hole about the size of a five-cent piece near his heart.

Each of the above accidents happened with voltages such as one is likely to encounter in lighting circuits about an industrial plant. Whether a test was made to ascertain what voltage actually existed in each of the above cases is not stated, but in other somewhat similar cases tests were made but failed to show more than the normal voltage. It would appear then that even a circuit of "only 110" volts may, under certain circumstances, be dangerous, and conditions under which boilers are inspected and cleaned are by no means the safest. In the first place the boiler has an excellent electrical connection with a feed water pipe and hence is well grounded. Furthermore, the man working in a boiler is usually perspiring rather freely so that his moist hand or any part of his body that touches the metal makes a fairly good connection. It remains only for a short circuit through the brass lamp socket or a frayed cord to send a charge through the man.

Whether a shock from a 110 or 220 volt source will prove fatal depends likewise upon considerations other than merely good connections. For instance, the body resistance of different persons varies over quite a range, just as do all other physical characteristics. Hence, a man having a low electrical resistance would receive a heavier current than a man of higher resistance. Since the action of an electric shock is a paralyzing or tightening of the muscles, the condition of the heart is also a governing factor.

Still another factor is the matter of time or duration of the shock. If a person receiving a shock is in such a position that he immediately recoils or falls away and breaks the connection, serious injury is not likely to result from moderate voltages. However, if the paralyzing effect prevents voluntary action or causes the victim to fall in such a way as to maintain contact, then the prolonged action of the current, as would be expected, multiplies the effect. This is of particular importance to men working in boilers where much of the work is performed in tight places and in a recumbent position, sometimes even with the light resting on the body in order to free both hands for the work.

It is advisable, therefore, when using portable electric lights around boilers, first, to use only such as have the socket encased with some non-conducting material, and second, to examine the equipment beforehand to be sure it is safe for use.

(W. E. S.)

TABLE NO. 1  
VARIETIES OF CANE

	H 109	Y. C.	D 1135	Yellow Tip	Striped Tip	Lahaina	Rose Bamboo	Others
H. C. & S. Co.....	86	..	11	..	..	3	..	2
Oahu .....	92	..	6	..	..	1	..	1
Ewa .....	99	..	21	..	..	..	..	4
Waialua .....	72	..	3	..	16	..	..	7
Pioneer .....	74	..	..	..	..	..	..	..
Olaa .....	..	89	11	..	..	..	..	..
Maui Agr. ....	78	..	..	..	13	3	..	1
Haw. Sug. ....	76	..	17	..	..	..	5	7
Lihue .....	49	31	1	16	..	..	..	3
Onomea .....	..	82	1	17	..	..	..	..
Hilo .....	..	92	7	..	..	..	..	1
Honolulu .....	96	3	1	..	..	..	..	..
Haw. Agr. ....	..	45	17	..	3	..	9	26
Kekaha .....	50	..	16	..	..	32	..	2
Hakalau .....	..	77	1	22	..	..	..	..
Wailuku .....	85	..	2	..	7	4	..	2
Makee .....	63	22	..	13	..	..	..	..
McBryde .....	59	18	18	..	..	..	..	5
Honokaa .....	5	9	84	..	..	..	..	2
Laupahoehoe .....	..	39	21	39	..	..	..	1
Hamakua .....	..	31	60	7	..	..	..	2
Pepeekeo .....	..	86	4	10	..	..	..	..
Kahuku .....	74	20	..	..	..	5	..	1
Paauhau .....	7	16	56	19	..	..	..	2
Honomu .....	..	98	1	..	..	..	..	1
Koloa .....	55	26	..	14	..	..	..	5
Waiakea .....	..	98	2	..	..	..	..	..
Hutchinson .....	..	41	17	..	..	..	42	..
Hawi .....	13	..	28	4	51	3	1	..
Kaiwiki .....	..	44	31	4	15	..	..	6
Waianae .....	100	..	..	..	..	..	..	..
Kohala .....	..	18	42	9	14	..	..	17*
Kilauea .....	19	7	8	32	5	..	..	29†
Waimanalo .....	92	6	1	..	..	..	..	1
Kaeleku .....	..	100	..	..	..	..	..	..
Union Mill .....	..	7	8	5	80	..	..	..
Halawa .....	..	21	36	..	43	..	..	..
Waimea .....	90	..	..	..	..	10	..	..
Niulii .....	..	34	21	28	17	..	..	..
Olowalu .....	73	..	..	..	..	27	..	..
True Average 1926.	48.7	25.6	12.1	4.5	2.1	1.5	1.5	2.9
" " 1925.	42.7	30.7	11.9	2.7	2.1	2.0	3.1	3.8
" " 1924.	38.1	32.6	12.0	2.3	2.0	2.5	4.4	4.7
" " 1923.	30.7	36.3	11.2	1.2	1.6	3.1	8.4	6.0
" " 1922.	21.1	40.3	12.2	2.7	1.6	2.8	12.0	5.7
" " 1921.	15.0	45.1	11.0	1.2	1.8	3.0	17.4	1.0
" " 1920.	9.1	42.7	10.0	1.4	2.1	2.5	26.7	0.8
" " 1919.	6.8	46.4	7.2	0.3	2.6	1.8	29.1	2.1
" " 1918.	4.0	42.9	7.5	0.5	1.5	0.6	37.9	1.1

\* 8% K 107

† Principally Badila.

## Annual Synopsis of Mill Data

By W. R. MC ALLEP

Though a few changes have been made in some of the tables, the Synopsis is presented in much the same form as in the past few years. It is again on the basis of the calendar year ending about the first of October, and factories are again listed in the tabulations according to the average size of the preceding five crops, except where otherwise noted. As sucrose data are now reported from seventy-five per cent of the factories, these data have been tabulated separately and averaged for the first time. Also for the first time it has been practicable to compile data for yield of cane per acre. Data for juice grooving and returner bar settings have been omitted. In recent years changes in these data from season to season have been comparatively few and a compilation every second or third year should serve all purposes. Data are included from all factories in the Association, representing the production of 782,643 tons of sugar.

### VARIETIES OF CANE

Eight varieties of cane are again classed as major varieties; that is, varieties making up 1 per cent or more of the total crop (Table 1). Changes in the proportion of these varieties have followed the general trend of the last few seasons. H 109 and Yellow Tip have materially increased. There is a tendency toward slight increases in D 1135 and Striped Tip, while Yellow Caledonia, Lahaina and Striped Mexican have materially decreased.

Almost one-half of the total production is H 109, establishing this variety in first place by a large margin. Yellow Caledonia and D 1135 are again second and third, the former making up approximately a quarter and the latter approximately one-eighth of the total. Yellow and Striped Tip rank fourth and fifth, Yellow Tip having displaced Lahaina, and Striped Tip both Lahaina and Striped Mexican. Ninety-three per cent of the total crop consists of these five leading varieties. Lahaina is now in seventh place, the proportion of this variety being less than half of what it was in 1925.

Minor varieties making up one per cent or more of the crop of any single plantation are in the following tabulation. The 1924 and 1925 figures are included for reference.

Variety	Per Cent of Total Crop		
	1924	1925	1926
Badila .....	.46	.35	.47
D 117 .....	.49	.52	.15
H 146 .....	.51	.26	.14
Uba .....	.03	.11	.10
K 107 .....	..	..	.07
Yellow Bamboo .....	.02	.14	.03
W 4 .....	..	..	.02
H 456 .....	..	.11	...
H 20 .....	..	.10	...
White Bamboo .....	.11	.06	...
H 227.....	..	.05	...
 Total.....	 1.62	 1.70	 .98

TABLE NO. 2  
COMPOSITION OF CANE BY ISLANDS

	Hawaii	Maui	Oahu	Kauai	Whole Group
1917					
Polarization .....	13.31	15.43	13.55	13.13	13.76
Per cent Fiber.....	13.23	11.67	12.25	12.89	12.62
Purity 1st Expressed Juice...	88.11	90.40	86.77	86.70	88.02
Quality Ratio .....	8.21	7.03	8.20	8.27	7.95
1918					
Polarization .....	11.88	14.25	13.50	12.54	12.97
Per cent Fiber.....	13.35	11.53	12.23	12.84	12.50
Purity 1st Expressed Juice...	87.27	88.62	86.93	85.88	87.18
Quality Ratio .....	9.27	7.73	8.27	8.60	8.47
1919					
Polarization .....	12.74	15.12	14.24	13.52	13.74
Per cent Fiber.....	13.07	11.74	12.14	12.61	12.49
Purity 1st Expressed Juice...	87.54	88.81	87.00	85.82	87.34
Quality Ratio .....	8.66	7.25	7.81	8.20	8.05
1920					
Polarization .....	12.86	15.29	13.75	13.07	13.64
Per cent Fiber.....	13.36	11.39	12.65	12.72	12.64
Purity 1st Expressed Juice...	87.87	88.94	85.40	86.52	87.24
Quality Ratio .....	8.45	7.08	8.07	8.28	8.00
1921					
Polarization .....	12.25	14.67	13.72	12.67	13.12
Per cent Fiber.....	13.28	11.82	12.40	13.28	12.80
Purity 1st Expressed Juice...	87.18	87.37	85.46	84.07	86.22
Quality Ratio .....	8.98	7.51	8.11	8.76	8.41
1922					
Polarization .....	12.07	13.95	13.61	13.03	12.97
Per cent Fiber.....	13.16	12.38	12.88	13.22	12.95
Purity 1st Expressed Juice...	87.17	87.88	86.18	85.80	86.84
Quality Ratio .....	9.19	7.75	8.04	8.36	8.45
1923					
Polarization .....	12.09	13.61	12.99	12.94	12.78
Per cent Fiber.....	13.14	12.01	12.86	12.99	12.82
Purity 1st Expressed Juice...	87.61	88.65	85.52	86.58	87.05
Quality Ratio .....	9.12	7.91	8.50	8.42	8.57
1924					
Polarization .....	12.44	14.34	13.48	13.34	13.26
Per cent Fiber.....	12.99	12.16	12.72	12.94	12.74
Purity 1st Expressed Juice...	87.98	89.19	87.02	87.31	87.86
Quality Ratio .....	8.86	7.58	8.16	8.12	8.25
1925					
Polarization .....	12.35	14.42	13.52	13.24	13.22
Per cent Fiber.....	12.92	12.40	12.60	12.91	12.74
Purity 1st Expressed Juice...	88.02	89.36	87.11	87.19	87.92
Quality Ratio .....	8.92	7.47	8.18	8.21	8.28
1926					
Polarization .....	12.53	14.66	13.40	13.03	13.24
Per cent Fiber.....	12.90	12.24	12.72	12.46	12.65
Purity 1st Expressed Juice...	87.59	89.03	86.61	86.68	87.45
Quality Ratio .....	8.80	7.40	8.29	8.39	8.30

D 117, which in 1923 ranked as a major variety, has since steadily decreased until but .15 per cent is reported this season. H 146 has also steadily decreased from a maximum of .93 per cent in 1921 to .14 per cent this season. H 456, H 20, White Bamboo and H 227, listed as minor varieties in 1925, are not so classed this year. Two new varieties are included for the first time, each reported from a single plantation. These are K 107, reported from Kohala Sugar Company, and W 4 reported from Wailuku.

#### QUALITY OF CANE

Notwithstanding an increase in cane polarization, the cane is of poorer quality than last year, due to lower purity. During the five preceding years there were increases in juice purity from season to season. This year a decrease of .47 brings the purity to a lower point than in 1924 and 1925, but higher than in other previous seasons since 1917. The quality ratio has increased from 8.28 to 8.30. This is a poorer quality ratio than in preceding seasons except 1918, 1921, 1922 and 1923.

Considering the Islands separately, we find decreases in purity in each instance. On Hawaii and Maui increases in polarization are large enough to more than offset the decreases in purity. Quality ratios are the best since 1920 on both of these Islands. On Oahu and Kauai there have been decreases in both polarization and purity. The quality ratio on Oahu is poorer than in any previous season except 1923; on Kauai it is poorer than in previous seasons except 1918, 1921 and 1923.

In quality of cane the Islands rank in the usual order; that is, Maui first, then Oahu, Kauai and Hawaii. The difference between Oahu and Kauai is small, amounting to but .1 in quality ratio.

Lower fiber is reported from all islands except Oahu, the average for the whole crop decreasing from 12.74 last year to 12.65. Figures for Hawaii and Kauai indicate consistent decreases in fiber from year to year; since 1920 on Hawaii and since 1921 on Kauai.

Tons cane per acre for the crop and for the five leading varieties are in the following table. These figures have been obtained by combining data reported for the Acreage Census and the Annual Synopsis. While a few discrepancies between the two sets of figures detract somewhat from the accuracy of the results, the figures for the crop and for the two leading varieties are probably accurate to within a few tenths, while probable errors in other figures will hardly exceed one ton per acre.

	Tons Cane Per Acre	
	1925	1926
Crop .....	53.3	54.4
H 109 .....	69.4	69.1
Yellow Caledonia .....	44.8	45.0
D 1135 .....	49.3	46.4
Yellow Tip .....	41.0	39.8
Striped Tip .....	31.5	37.0

The increase of 1.1 tons per acre for the entire crop seems due largely to increased acreage of H 109 in 1926.

TABLE NO. 3

True Averages of All Factories Except Those Now Using the Petree Process

	1922	1923	1924	1925	1926
Cane—					
Polarization .....	12.77	12.66	13.08	12.99	12.99
Fiber .....	13.03	12.91	12.82	12.80	12.71
Tons per ton sugar.....	8.76	8.68	8.40	8.45	8.50
Bagasse—					
Polarization .....	1.71	1.53	1.52	1.54	1.58
Moisture .....	41.31	41.29	41.26	41.25	41.09
Fiber .....	56.23	56.48	56.74	56.55	56.64
Polarization per cent cane.....	0.40	0.35	0.34	0.35	0.35
Pol. per cent. pol. of cane.....	3.11	2.76	2.63	2.69	2.73
Milling loss .....	3.05	2.71	2.68	2.73	2.79
Weight per cent cane.....	23.16	22.84	22.59	22.63	22.44
FirstExpressedJuice—					
Brix .....	18.23	17.99	18.34	18.14	18.24
Polarization .....	15.79	15.61	16.07	15.91	15.88
Purity .....	86.58	86.77	87.61	87.67	87.05
"Java ratio" .....	80.9	81.1	81.4	81.7	81.8
Mixed Juice—					
Brix .....	13.26	13.11	13.37	13.44	13.65
Polarization .....	11.07	11.00	11.31	11.38	11.48
Purity .....	83.50	83.87	84.56	84.67	84.12
Weight per cent cane.....	111.65	111.95	112.66	111.03	110.10
Polarization per cent cane.....	12.38	12.31	12.74	12.64	12.64
Extraction .....	96.89	97.24	97.37	97.31	97.27
Extraction ratio.....	0.24	0.21	0.21	0.21	0.21
LastExpressedJuice—					
Polarization .....	1.96	1.73	1.84	1.90	2.06
Purity .....	68.66	68.48	71.73	69.63	68.72
Maceration per cent cane.....	34.99	34.79	35.30	33.66	32.54
Syrup—					
Brix .....	63.11	63.33	63.18	63.63	64.21
Purity .....	84.81	85.40	86.02	85.95	85.49
Increase in purity.....	1.31	1.53	1.46	1.28	1.37
Lime used per cent cane.....	0.081	0.085	0.086	0.078	0.083
Press Cake—					
Polarization .....	1.96	2.20	2.16	2.17	2.49
Weight per cent cane.....	2.49	2.45	2.45	2.45	2.63
Polarization per cent cane.....	0.05	0.05	0.05	0.05	0.07
Pol. per cent. pol. of cane.....	0.38	0.43	0.40	0.41	0.50
Commercial Sugar—					
Polarization .....	96.88	96.88	97.20	97.23	97.29
Moisture .....	0.85	0.80	0.73	0.74	0.66
Weight per cent cane.....	11.41	11.53	11.91	11.83	11.77
Polarization per cent cane.....	11.06	11.17	11.58	11.50	11.45
Pol. per cent. pol. of cane.....	86.94	88.37	88.76	88.78	88.41
Pol. per cent pol. of juice.....	89.69	90.86	91.16	91.24	90.95
Final Molasses—					
Weight per cent cane.....	3.14	2.96	2.83	2.82	2.94
Sucrose per cent cane.....	1.07	0.99	0.97	0.93	0.99
Sucrose per cent pol. of cane....	8.33	7.79	7.45	7.20	7.63
Sucrose per cent pol. of juice....	8.60	8.01	7.65	7.40	7.84
Gravity solids.....	87.94	88.54	89.08	90.09	89.59
Gravity purity.....	38.60	37.68	37.81	36.97	37.62
Undetermined Losses—					
Polarization per cent cane.....	0.21	0.11	0.14	0.16	0.13
Pol. per cent. pol. of cane.....	1.28	0.65	0.76	0.92	0.73

## CHEMICAL CONTROL.

Three additional factories have reported sucrose data, bringing the total so reporting to thirty. These data have not been averaged in previous years, because of the comparatively small proportion of the crop represented. However, the proportion has increased from year to year until now approximately 80 per cent of the crop is produced by factories reporting sucrose data. A start has been made toward giving these data more detailed consideration by compiling Table 7, containing available sucrose data and true averages.

Molasses data also are more complete than in the past. But four factories have failed to report the amount of final molasses either on the basis of weights or measurements, against seven last year. Two additional factories have installed molasses scales, making a total of twenty-seven weighing the final molasses.

There has been no change in the number of factories weighing the juice, thirty-six factories reporting actual mixed juice weights, while the chemical control at four factories is still based on juice measurements.

The influence of a change in analytical methods must be taken into consideration when comparing molasses purities with figures for previous years. According to work at this Station, gravity purities by the new dry lead method average approximately .6 lower than by the old wet lead method. This difference is influenced by the density and purity of the sample and by the composition of the non-sugars. It therefore may be expected to vary in individual samples and in molasses from different factories. The .6 correction should be quite constant, however, for crop averages for different years. The new method was adopted prior to the 1925 season, and 1925 data, except for a moderate amount at the beginning of the season, were on this basis. The 1925 and 1926 averages, therefore, are not exactly on the same basis, but the difference is small and no material error will be involved in considering figures for these two years comparable. Comparisons will be made, therefore, assuming that .6 must be subtracted from molasses purities for years prior to 1925 to render them comparable with averages for subsequent years.

Lime figures also are not exactly comparable with figures for previous years. Formerly the total weight of lime was reported, a correction to available CaO being made only when hydrated lime had been used. Reports on the basis of available CaO have been requested this season, and as this request seems to have been quite generally complied with, the average figure for lime used is probably slightly low in comparison with previous data. Up to the present time, data for the amount of lime used have been the only basis available for judging clarification reactions and have, therefore, been of considerable significance. pH determinations are now made at most of the factories, and probably such data will be available for future Synopses, in which case it will no longer be necessary to base deductions as to the trend of clarification practice on the amount of lime used, a figure which at best is far from satisfactory for this purpose.

Table 4 contains comparisons of boiling house recovery with the available calculated on polarization data; also figures for molasses produced on the theoretical, assuming, as in previous seasons, the theoretical solids in molasses to be solids in syrup less solids accounted for in the sugar. Comparisons of boiling house recovery with the available, calculated on sucrose data, are in Table 5.

TABLE NO. 4  
APPARENT BOILING-HOUSE RECOVERY

Comparing per cent available sucrose in the syrup (calculated by formula) with per cent polarization actually obtained.

Factory	Available*	Obtained	Recovery on Available	Molasses Produced on Theoretical†
H. C. & S. Co.....	92.81	92.73	99.9	87.5
Oahu.....	92.07	92.48	100.4	74.7
Ewa .....	91.55	92.13	100.6	91.3
Waialua .....	91.19	91.87	100.7	87.0
Pioneer .....	92.74	93.36	100.7	85.7
Olala .....	91.67	91.12	99.4	98.6
Maui Agr.....	91.64	92.59‡	101.0	93.6
Haw. Sug.....	93.82	94.01	100.2	104.7
Lihue .....	90.75	91.33	100.6	82.1
Onomea .....	92.42	92.95	100.6	89.3
Hilo .....	91.62	91.59	100.0	86.1
Haw. Agr.....	90.53	89.97	99.4	89.3
Kekaha .....	90.78	90.89	100.1	87.5
Hakalau .....	92.21	93.00	100.9	85.0
Wailuku .....	92.10	93.01	101.0	89.8
Makee .....	89.05	88.60	99.5	92.9
McBryde .....	91.53	90.56	98.9	96.7
Honokaa .....	90.15	90.81	100.7	91.8
Laupahoehoe .....	92.39	91.75	99.3	86.3
Hamakua .....	91.31	91.59	100.3	89.4
Pepeekeo .....	93.56	93.34	99.8	88.3
Kahuku .....	89.29	91.54	102.5	92.0
Paauhau .....	91.86	92.08	100.2	91.1
Honomu .....	92.43	92.36	99.9	92.9
Koloa .....	89.79	90.30	100.6	88.5
Waiakea .....	89.87	89.86	100.0	92.2
Hutchinson .....	89.42	88.67	99.2	96.6
Hawi .....	89.71	88.57	98.7	76.9
Kaiwiki .....	92.82	91.28	98.3	90.2
Waianae .....	86.97	82.87	95.3	...
Kohala .....	92.72	92.42	99.7	93.8
Kilauea .....	86.39	86.67	100.3	86.2
Waimanalo .....	89.38	90.04	100.7	86.8
Kaeleku .....	88.49	84.14	95.1	85.6
Union Mill.....	90.42	89.76	99.3	96.2
Halawa .....	90.14	89.37	99.1	...
Waimea .....	90.90	88.02	96.8	...
Niuli .....	91.30	89.17	97.7	...
Olowalu .....	90.86	86.71	95.4	62.5

\* In order to calculate the available sucrose it is necessary to estimate the gravity purity of the syrup and sugar. Data from factories determining both apparent and gravity purities indicate that the average correction necessary is the addition of 0.8 to the apparent purity of the syrup and 0.3 to the apparent purity of the sugar. When the moisture in the sugar has not been reported 1 per cent has been taken. 38 has been used when the gravity purity of the molasses has not been reported.

† Gravity solids in syrup, less solids accounted for in commercial sugar considered as theoretical gravity solids in final molasses.

‡ Sucrose.

This season figures for molasses produced on theoretical, based on the amount of molasses indicated by the S. J. M. formula, have been included in this table.

This year the number of factories reporting 100 per cent or more on available is larger than in any previous season, twenty in Table 4 and eleven in Table 5. However, one factory only has reported in excess of 101 per cent, a record equaled in but one previous season, 1921.

The true average of figures in Table 4 for molasses produced on theoretical is 90.4, a figure slightly higher than the average for the five previous seasons, 88.8. While wide variations are still evident in some of these figures, the general tendency from year to year has been toward fewer wide variations from the average. Figures in Table 5, for molasses produced on the theoretical as indicated by the S. J. M. formula, average slightly higher than corresponding figures in Table 4. This method of calculating the theoretical amount of molasses would have been used in previous Synopses had a greater number of factories reported sucrose data.

The "available" in Tables 4 and 5 represents the recovery indicated by the S. J. M. formula rather than the amount of sucrose it is possible to recover, for the calculations are based on purities as reported without reference to whether or not larger purity increases in clarification or lower molasses purities could have been realized. These calculations are therefore largely checks on the chemical control, though low figures for recovery on available may reflect losses. Such calculations are useful for disclosing large discrepancies in the chemical control. They have been particularly useful in the past, when juice entering, and molasses leaving the house were largely estimated from measurements. Brix hydrometers were less carefully calibrated and the chemical control in general was less accurate than at present. Data now available, however, give many indications that the value for available sucrose as calculated is somewhat lower than the true theoretical figure for available. Notwithstanding more reliable chemical control, coincident with the use of larger amounts of lime in clarification and generally better boiling house work in recent years, an increasing number of factories have reported in excess of 100 per cent recovery on available. As previously mentioned, the maximum number have so reported this year. Critical examination of control methods discloses several small factors tending toward low figures for calculated available. While this does not interfere with the use of these calculations for disclosing comparatively large discrepancies in control data, if closer comparisons are desired the influence of these factors must be taken into consideration. While this subject was taken up in the 1924 Synopsis, we will consider it again briefly. The following four factors were discussed at that time:

1. Solids in sugar are determined by drying. "True" purity figures thus secured are slightly higher than gravity purities on which the calculation is based. The calculated available decreases as sugar purity increases. Consequently, as our figure for sugar purity is relatively higher than the syrup and molasses purities, this tends toward low figures for available.

2. There was an error in the former method of determining sucrose in molasses which resulted in a purity figure relatively too high. As an increase in molasses purity reduces the calculated available, this also has tended toward low figures for available. This error is now corrected.

TABLE NO. 5  
TRUE BOILING-HOUSE RECOVERY  
Comparing per cent sucrose available and recovered

Factory	Available	Obtained	% Recovery on Available	Molasses Produced on Theoretical*
H. C. & S. Co.....	92.73	92.15	99.4	90.2
Oahu.....	92.21	91.66	99.4	76.4
Ewa.....	91.71	91.00	99.2	92.3
Waialua.....	91.06	90.63	99.5	84.5
Pioneer.....	92.71	92.71	100.0	85.0
Maui Agr.....	91.64	92.57	101.0	90.1
Haw. Sug.....	93.93	93.31	99.3	108.9
Lihue.....	90.85	90.36	99.5	82.0
Onomea.....	92.73	92.76	100.0	93.8
Hilo.....	91.32	91.54	100.2	85.7
Haw. Agr.....	90.71	89.22	98.4	95.3
Hakalau.....	92.15	92.66	100.6	83.4
Wailuku.....	92.15	92.59	100.5	87.9
Makee.....	89.12	87.98	98.7	96.7
McBryde.....	91.64	89.61	97.8	104.3
Honokaa.....	90.11	90.36	100.3	91.2
Laupahoehoe.....	92.07	91.45	99.3	88.0
Hamakua.....	91.20	91.29	100.1	90.2
Pepeekeo.....	93.32	93.04	99.7	87.9
Kahuku.....	89.37	90.39	101.1	87.3
Paauhau.....	91.75	91.91	100.2	90.1
Honomu.....	92.38	91.85	99.4	94.1
Koloa.....	89.98	89.19	99.1	89.9
Waiakea.....	89.66	89.20	99.5	92.5
Hutchinson.....	89.44	88.30	98.7	102.1
Kilauea.....	86.53	85.56	98.9	86.3
Waimanalo.....	89.21	89.64	100.5	84.2
Union Mill.....	90.10	89.58	99.4	98.8
Olowalu.....	90.77	86.29	95.1	74.4

\* Calculated by the S. J. M. formula.

3. A discrepancy in the Brix of final molasses. This is determined in a solution containing a higher concentration of non-sugars than the syrup, it being impracticable to make these determinations at equivalent concentrations. The relative amount of non-sugars indicated by the Brix decreases as the concentration of non-sugars in the solutions in which the determination is made increases. Consequently the value obtained for molasses purity is relatively higher than the syrup purity. This factor also tends to reduce the figure for calculated available.

4. Volatilization of solids during boiling operations. This undoubtedly takes place to some extent. It amounts to increasing the purity over that of the syrup on which the calculation is based. This also tends toward a low figure for available.

To the above may be added two additional factors:

5. Formation of scale in the pans. This affects the calculation in the same way as volatilization of solids. While this factor is very small, it should be noted that when the scale-forming constituents were in solution in the syrup they increased the gravity solids by considerably more than their actual weight.

6. Precipitation of non-sugar subsequent to the syrup stage. Non-sugar crystals, largely inorganic in composition, can almost invariably be found in massecuite and molasses. Organic matter also separates out due to concentration and decrease in pH. In so far as this precipitated matter is retained in the commercial sugar, the effect is that discussed under No. 1 above. The remainder, as suspended matter in molasses, influences the reading of the Brix hydrometer much less than when in solution in the syrup. This is another factor tending toward a relatively low molasses Brix and therefore a relatively high purity. It therefore tends to depress the calculated available.

These factors all influence the calculations in the same direction. So far as conclusions can be drawn from available data, the combined effect is not large, probably in the neighborhood of one per cent in calculations on a true sucrose basis.

The influence of these factors on the calculated theoretical amount of molasses is in the opposite direction, and is much larger. So far as can be inferred from data in recent Synopses, the calculated amount of molasses is in the neighborhood of 10 per cent too high.

Deerr's S. J. M. formula, used in these calculations, divides a syrup of a given purity into molasses and sugar of given purities with mathematical accuracy. Discrepancies are due to data on which the calculation is based rather than the calculation itself. The error in molasses analysis is now corrected and need not be considered further. Volatilization of solids and scale in the pans are probably of minor importance. Factors 1, 3 and 6, which are probably responsible for the greater part of the discrepancy, are due to basing calculations on gravity solids as indicated by the Brix hydrometer, and would be eliminated if the control were based on the actual weight of solids. Unfortunately, methods so far developed for determining total solids are not well suited to routine factory control, and changing to this basis is impracticable until more suitable methods are developed. The writer wishes to emphasize the point that the influence of these factors should be taken into consideration in drawing conclusions from factory control data.

TABLE NO. 6  
GRAVITY SOLIDS AND SUCROSE BALANCES

Factory	GRAVITY SOLIDS PER 100 GRAVITY SOLIDS IN MIXED JUICE				SUCROSE PER 100 SUCROSE IN MIXED JUICE			
	Press Cake	Commercial Sugar	Final Molasses	Undeter- mined	Press Cake	Commercial Sugar	Final Molasses	Undeter- mined
H. C. & S. Co. ....	3.3	80.6	14.1	2.0	0.88	91.34	6.50	1.28
Oahu ....	4.1	78.2	13.2	4.5	0.73	91.00	5.91	2.36
Ewa ....	5.4	75.1	17.5	2.0	0.41	90.63	7.62	1.34
Wai'alua ....	3.0	77.2	16.4	3.4	0.45	90.22	7.52	1.81
Pioneer ....	4.8	78.2	14.5	2.5	0.67	92.09	6.16	1.08
Maui Agr. ....	..	82.4	16.5	1.1	..	92.57	7.53	-0.10
Haw. Sug. ....	5.2	80.3	15.2	-0.7	0.38	92.96	6.58	0.08
Lihue ....	3.2	75.1	17.4	4.3	0.74	89.69	7.44	2.13
Onomea ....	6.1	77.4	15.5	1.0	0.13	92.64	6.81	0.42
Hilo ....	7.5	74.1	15.9	2.5	0.30	91.27	7.42	1.01
Honolulu ....	4.0	74.6	19.7	1.7	0.44	88.65	8.87	2.04
Haw. Agr. ....	3.7	75.3	18.8	2.2	0.47	88.80	8.81	1.92
Hakalau ....	3.5	78.5	15.4	2.6	0.14	92.53	6.54	0.79
Wailuku ....	4.1	79.2	15.0	1.7	0.52	92.11	6.86	0.51
Makee ....	3.1	72.7	22.5	1.7	0.51	87.53	10.47	1.49
McBryde ....	3.6	75.8	19.7	0.9	0.25	89.39	8.70	1.66
Honokaa ....	5.6	73.7	19.1	1.6	0.58	89.8+	8.97	0.61
Laupahoehoe ....	3.3	79.4	14.8	2.5	0.34	91.14	6.96	1.56
Hamakua ....	..	81.7	16.3	2.0	..	91.29	7.94	0.77
Pepeekeo ....	4.0	79.2	14.6	2.2	0.21	92.84	5.86	1.09
Kahuku ....	3.9	72.7	21.2	2.2	0.34	90.08	9.25	0.33
Paahau ....	4.6	77.2	16.5	1.7	0.15	91.77	7.42	0.66
Honomu ....	4.9	77.1	16.5	1.5	0.26	91.61	7.15	0.98
Koloa ....	5.5	72.3	19.4	2.8	1.05	88.25	8.92	1.78
Waiakea ....	4.3	75.5	18.3	1.9	0.48	88.77	9.51	1.24
Hutchinson ....	7.9	70.8	20.7	0.6	0.67	87.71	10.69	0.93
Kilauea ....	3.6	67.5	24.3	4.6	0.96	84.74	11.51	2.79
Waimanalo ....	5.6	72.4	18.8	3.2	0.50	89.19	9.03	1.28
Union Mill ....	4.7	75.7	18.9	0.7	0.91	88.76	9.69	0.64
Olowalu ....	4.7	72.0	14.6	8.7	0.59	85.78	6.83	6.80

Gravity solids and sucrose balances for factories reporting on a sucrose basis are in Table 6.

While data in Tables 4, 5 and 6, considered in relation to the factors discussed above, permit us to draw fairly definite inferences as to whether or not there are material discrepancies in control figures, arriving at definite standards on which to base comments on the accuracy of such figures is somewhat unsatisfactory, not only because this involves deciding on what should be considered moderate errors, but also because of our limited knowledge of the exact influence of the factors previously discussed. Assuming tentatively that reasonably accurate data do not indicate negative undetermined losses of either solids or sucrose, more than 101 per cent recovery of sucrose on available, or more than 95 per cent of the calculated amount of molasses, particularly on the basis of calculations in Table 5, we find the following factories exceeding these limits: A negative undetermined loss of solids at Hawaiian Sugar Company; a negative undetermined loss of sucrose at Maui Agricultural Company; over 101 per cent recovery of sucrose on available at Kahuku; more than 95 per cent of molasses on available at Hawaiian Sugar Company, McBryde, Hutchinson, Union Mill and Hawaiian Agricultural Company. A normal amount of molasses is shown for the latter factory, however, by figures in Table 4.

In the last few years there have been changes in the basis on which data from certain factories have been reported, influencing many of the averages and necessitating supplementary calculations when studying data to ascertain the probable effect on figures under consideration. This has materially complicated the preparation of the Synopsis and in many cases it has been found impracticable to draw deductions even where such deductions would have been of considerable significance. The disturbing effect of Petree process figures has been discussed in previous Synopses and a table containing averages for the factories which do not use this process has been compiled each year to partially remedy this difficulty. The influence of a change in the method of molasses analysis must also be taken into consideration when comparing molasses data with previous years. Another disturbing factor is averaging some sucrose data with data on a polarization basis. For many years one of the larger factories has reported sucrose only for mixed juice, syrup and sugar, instead of both polarization and sucrose. Though a discrepancy is introduced by including such data in polarization averages, this has not complicated comparisons with other seasons, as data have been on the same basis from year to year. However, in 1923 a second, and in 1925 a third large factory reported on this basis. As but one factory changed in a single season, discrepancies in the averages between any two years have been small in most instances, and to avoid complicating the Synopsis these discrepancies have been pointed out only where they were of sufficient size to influence conclusions. This season polarization data have been secured from these two factories, and many of the averages have been influenced to the extent that it has been necessary to prepare the following table, calculated on the basis of sucrose data from these two factories. Where figures in this table differ from averages in the large table and Table 3, comparisons with 1925 data will be on the basis of the figures given below. These will be referred to as "figures calculated on a basis comparable with last season."

TABLE NO. 7  
SUCROSE DATA

Factory	MIXED JUICE		SYRUP		SUGAR		Undeter-mined Loss per 100 Sucrose* in cane	
	Cane Sucrose*	Sucrose	Gravity Purity	Gravity Purity	Increase in Purity	Sucrose		
H. C. & S. Co. ....	14.97	12.46	88.80†	88.80	0	97.43	89.43	1.25
Oahu. ....	14.08	12.61	86.67	87.58	0.91	97.90	88.76	2.30
Ewa. ....	13.14	11.27	83.67	85.63	1.96	97.53	88.84	1.32
Waialua. ....	13.89	12.06	85.90	86.30	0.40	97.53	87.71	1.76
Pioneer. ....	14.60	13.37	86.26	87.38	1.12	98.14	89.83	1.06
Maui Agr. ....	15.37	11.67	87.48†	87.60	0.12	97.77	88.81	-0.10
Haw. Sug. ....	14.80	12.94	88.03	89.28	1.25	97.79	90.72	0.08
Libue. ....	12.64	12.43	84.73	84.60	-0.13	97.86	86.88	2.06
Onomea. ....	12.18	10.26	85.36	87.58	2.22	97.79	91.47	0.41
Hilo. ....	12.21	10.59	84.31	86.18	1.87	97.68	89.62	1.00
Honolulu. ....	14.04	11.82	85.34	87.25	1.91	100.0	86.26	1.99
Haw. Agr. ....	12.09	11.69	85.27	86.23	0.96	97.63	86.01	1.86
Hakalau. ....	12.41	10.40	85.10	86.00	0.90	97.04	91.51	0.78
Wailuku. ....	14.29	11.61	86.84	87.70	0.86	97.71	90.73	0.50
Makee. ....	12.06	11.03	83.44	84.13	0.69	97.99	84.12	1.43
McBryde. ....	13.64	11.95	85.06	86.10	1.01	97.47	86.88	1.61
Honokaa. ....	11.44	10.64	83.19	84.57	1.38	97.29	86.03	0.58
Laupahoehoe. ....	13.11	10.69	87.70	88.49	0.79	97.87	88.52	1.51
Hamakua. ....	13.54	13.47	88.10†	88.32	0.22	97.77	88.70	0.75
Pepeekeo. ....	12.53	11.31	85.62	87.10	1.48	97.72	90.83	1.07
Kahuku. ....	12.25	10.55	81.40	82.33	0.93	97.91	87.78	0.32
Paaulau. ....	12.45	11.05	84.61	86.63	2.02	97.82	89.46	0.65
Honomu. ....	12.70	10.63	84.44	86.70	2.26	97.74	89.90	0.96
Koloa. ....	12.75	11.15	83.09	84.30	1.21	97.73	85.44	1.73
Waiakea. ....	13.42	12.17	85.64	86.79	1.15	97.29	84.69	1.18
Hutchinson. ....	12.06	11.24	84.32	85.80	1.48	97.78	84.02	0.89
Kilauea. ....	11.37	10.61	80.81	81.00	0.19	98.33	82.47	2.71
Waimanalo. ....	11.96	10.70	81.90	84.14	2.24	97.70	87.91	1.26
Union Mill. ....	12.57	11.84	85.80	86.80	1.00	96.62	83.86	0.60
Olowalu. ....	14.14	11.78	84.45	85.70	1.25	96.81	83.77	6.64
True Average. ....	13.39	11.69	85.51	86.68	1.17	97.77	88.32	1.24

\* Polarization in bagasse and press cake has been used in this calculation. no account being taken of the difference between sucrose and polarization in these products.

† Clarified juice.

	Large Table	Table 3
Cane Polarization .....	13.26	13.01
Java Ratio .....	81.84	81.9
Mixed Juice Polarization .....	11.60	11.50
Mixed Juice Purity .....	84.76	84.26
Mixed Juice Polarization % Cane.....	12.90	12.66
Syrup Purity .....	85.90	85.63
Sugar Polarization .....	97.34	97.34
Recovery % Polarization in Cane.....	88.53	88.36
Recovery % Polarization in Juice.....	91.03	90.83
Sucrose in Molasses % Pol. in Cane.....	7.50	7.62
Sucrose in Molasses % Pol. in Juice.....	7.71	7.83
Undetermined Loss .....	.72	.80

### MILLING

This year the average grinding rate has increased materially while the average extraction has decreased slightly. Data for grinding rates and also tons pressure per foot of roller for the last few seasons are in the following table:

Year	Tons Cane Per Hour	Tonnage Ratio	Tons Pressure Per Linear Foot of Roller
1920	39.34	...	...
1921	36.58	1.40	...
1922	39.93	1.54	65.2
1923	42.03	1.56	66.2
1924	43.63	1.62	66.9
1925	45.31	1.71	66.5
1926	46.43	1.78	67.4

The increase in grinding rate over last season is 1.12 tons per hour, corresponding to an increase of .07 in tonnage ratio. Such increases conform to the tendency toward higher grinding rates during the past few seasons. The tendency has been general this year, approximately two-thirds of the factories reporting higher tonnage ratios.

The above data for tons pressure per linear foot of roller show a well-defined tendency toward higher pressures during the past few seasons. The reported increase over last season is slightly less than one ton per foot of roller.

Maceration is very nearly the same as in the previous season, though the slight difference, a reduction from 33.63 to 33.61, conforms to the tendency toward lower maceration during the past seven years. Twenty-one factories report decreases, against nineteen reporting increases. It was somewhat interesting to note that but five factories report as heavy maceration as the average for all factories in 1919, the year in which maceration reached a maximum.

Moisture in bagasse has decreased from 41.56 to 41.48. Bagasse fiber has increased slightly: 56.18 to 56.19. With slightly higher fiber in bagasse and lower fiber in cane the calculated weight of bagasse per 100 cane has been reduced from 22.67 to 22.52. Polarization in bagasse has increased from 1.58 to 1.62, an increase large enough to offset the reduction in weight and increase the loss in bagasse per

TABLE NO. 8—MILLING RESULTS

Showing the Rank of the Factories on the Basis of Milling Loss.

Rank	1925 Rank	Factory	Milling Loss	Extraction Ratio	Extraction	Maceration	Tonnage Ratio	Tonnage Fiber Ratio*
1	1	Hakalau.....	1.10	0.10	98.88	38.46	1.53	19.14
2	3	Onomea.....	1.21	0.10	98.72	38.47	1.83	23.53
3	2	Waimanalo.....	1.30	0.11	98.56	31.62	2.06	26.92
4	4	Hilo.....	1.63	0.13	98.19	36.02	1.65	22.24
5	6	Kekaha.....	1.78	0.13	98.45	31.14	1.60	18.95
6	8	Wailuku.....	1.84	0.13	98.48	41.13	1.18	13.76
7	7	Honomu.....	1.94	0.15	98.12	38.42	1.49	18.12
8	11	Ewa.....	2.13	0.16	98.00	36.63	1.71	20.76
9	9	Pepeekeo.....	2.17	0.17	97.82	28.88	1.62	20.28
10	15	Kahuku.....	2.28	0.19	97.41	36.31	1.54	21.13
11	5	Olowalu.....	2.31	0.17	97.62	41.13	1.61	23.18
12	10	Paauhau.....	2.41	0.20	97.47	31.95	1.19	15.40
13	23	Oahu.....	2.66	0.19	97.51	31.91	1.86	24.11
14	30	H. C. & S. Co.	2.67	0.18	97.89	37.43	1.90	22.33
15	22	Hamakua.....	2.67	0.20	97.15	24.02	1.50	21.62
16	16	Pioneer.....	2.76	0.19	97.52	30.65	2.18	28.25
17	13	Kilauea.....	2.78	0.25	97.27	24.23	1.52	16.64
18	17	McBryde.....	2.78	0.21	97.16	34.78	1.24	17.04
19	18	Haw. Sug.....	2.85	0.19	97.56	33.51	1.43	17.95
20	14	Koloa.....	2.89	0.23	96.78	35.63	1.37	19.19
21	19	Laupahoehoe..	2.90	0.22	97.10	41.08	1.61	20.80
22	27	Haw. Agr.....	2.96	0.25	96.82	22.80	1.84	23.63
23	20	Waialua.....	3.00	0.22	97.17	34.98	2.29	29.52
24	21	Honolulu.....	3.21	0.23	97.27	38.56	1.54	18.50
25	24	Olaa.....	3.21	0.24	96.88	32.01	2.03	26.11
26	12	Lihue.....	3.35	0.27	96.82	20.31	1.90	22.50
27	29	Kohala.....	3.41	0.24	97.14	37.70	1.65	19.37
28	26	Makee.....	3.64	0.30	96.07	28.16	2.01	25.89
29	28	Waimea.....	3.65	0.27	96.69	25.83	1.49	18.01
30	25	Watianae.....	3.71	0.29	95.86	41.90	1.58	22.93
31	36	Honokaa.....	3.82	0.34	95.72	27.17	1.58	19.99
32	33	Hawi.....	3.93	0.30	96.39	27.35	1.70	20.59
33	32	Kaiwiki.....	3.97	0.29	96.15	31.87	1.68	21.99
34	37	Kaeleku.....	4.15	0.36	95.07	32.58	1.83	25.40
35	35	Waiakea.....	4.37	0.33	95.37	31.17	1.54	21.70
36	34	Hutchinson....	4.52	0.38	95.76	22.23	1.89	21.22
37	38	Union Mill....	4.84	0.39	94.45	26.67	1.83	26.33
38	31	Maui Agr.....	5.10	0.33	95.94	51.45	2.43	29.82
39	39	Halawa.....	5.84	0.46	93.66	26.52	1.62	22.24
40	40	Niulii.....	6.30	0.50	93.28	20.05	1.73	23.41

\* Tonnage ratio multiplied by per cent fiber in cane.

cent polarization in cane from 2.71 to 2.75. The corresponding decrease in extraction is from 97.29 to 97.25. The decrease in extraction is somewhat less than if the cane had been as high in fiber as last year. The increase from 2.82 to 2.88 in loss per cent fiber in the bagasse or milling loss is relatively larger than the decrease in extraction.

At H. C. & S. Company, Petree process mud has been taken from the mills with a gain in extraction, while at Maui Agricultural Company the mill has been under reconstruction during the grinding season, seriously handicapping the work and causing a loss in extraction. In each case the influence of the change on the average for extraction has been as great as the difference between the averages for this year and the previous season. The trend toward lower extraction indicated by the averages, however, is also indicated by data for individual factories, twenty-six reporting increases in milling loss against twelve reporting decreases.

No factory has equaled previous records in either extraction, extraction ratio, or milling loss. The number of factories reporting over 98 extraction has decreased from nine in 1925 to eight this year. We also find a decrease of one in the number of factories reporting under 2.0 milling loss, seven factories so reporting against eight last year.

Factories are listed in the order of the size of the milling loss in Table 8. Several changes have been made in this table following suggestions that have been received. A second column at the left of the table indicates the 1925 ranking. Maceration, tonnage ratio and tonnage fiber ratio have been included, data for milling machinery being omitted. Tonnage fiber ratio, a figure used to a considerable extent in the Philippines, is the tonnage ratio multiplied by the per cent fiber in cane. The largest changes in relative rank are improvements of 10 and 16 by Oahu and H. C. & S. Company, and a drop of 14 by Lihue. Kahuku, Hamakua, Hawaiian Agricultural and Honokaa have all materially bettered their relative standing, while Olowalu, Koloa, Waianae and Maui Agricultural Company have all dropped five or more places.

Data for non-Petree process factories, calculated to a basis comparable with the previous seasons indicate a decrease of .21 in the drop in purity from first expressed to mixed juice. The tendency has been quite general, twenty-three of these factories reporting a smaller drop, against thirteen larger. This may reflect either cleaner conditions around the mill, less trash on the cane, or both.

#### BOILING HOUSE WORK

*Clarification:* Averages for non-Petree process factories in Table 3 indicate an increase in lime consumption, a larger increase in purity, higher recovery on available, and smaller undetermined loss. These changes conform to the relation shown by data in this table for other seasons. With the single exception of changes between the seasons 1923 and 1924, changes in increase in purity and recovery on available have been in the same direction as changes in the amount of lime used, while changes in the figures for undetermined loss have been in the opposite direction.

Lime consumption has increased from .078 to .083 per cent on cane; possibly the increase is slightly greater, due to the change in the way lime is reported. The improvement in the increase in purity is from 1.28 to 1.37. The improvement

has not been general, but sixteen out of thirty-seven factories reporting a larger increase. It reflects rather the results secured at the larger factories, eight of the ten largest reporting larger increases. While on the basis of average figures, the increase in lime has been accompanied by a larger increase in purity, examination of data for individual factories this season does not show a consistent relation. There are some indications that this may be due to a number of factories using the full amount of lime giving the maximum increase in purity, or even in excess of this amount, though study of this point is considerably complicated by the incomplete way in which lime used at the filter presses is reported, and also possibly to the change in the basis for reporting the amount of lime. When pH data are available the study of clarification on the basis of results secured by factories as a whole will be greatly facilitated. However, in view of the consistent manner in which averages for increase in purity, recovery on available, and undetermined loss in different seasons follow fluctuations in the amount of lime used, it seems reasonable to infer that, considered as a whole, the amount of lime used in clarification is still below the point giving the best results.

Averages for all factories in the large table also show an increase in lime, an increase in recovery on available, and a decrease in undetermined loss. The increase in lime, .002 per cent, is much smaller than shown in Table 3. This is also true of changes in recovery on available and undetermined loss. The latter figure, recalculated to a basis comparable with last season, is but .01; a change too small to be of significance in a figure such as undetermined loss, which is influenced by the sum of errors in all other figures in the polarization balance. It is, however, in the expected direction.

*Filter Presses:* Data for filter press work are much less satisfactory than last year. Twenty-two out of thirty-seven factories report an increase in press cake per cent cane; the same number report an increase in polarization of press cake, resulting in an increase in weight from 2.45 to 2.63 per cent on cane, an increase in polarization from 2.17 to 2.49, and an increase in the loss per cent polarization of cane from .41 to .50. The above refers to data in Table 3. The average loss in press cake per cent polarization of cane for all factories, shown in the large table, has increased from .38 to .50; a larger increase than is shown in Table 3. This is due to losses in mud reported from H. C. & S. Co., where this year all the mud has been treated in Kopke centrifugal separators, none being returned to the mill. Notwithstanding the limited capacity of the centrifugal installation, which limits the extent to which the sucrose content of the mud can be reduced, data reported show a smaller combined loss of sucrose in bagasse and Kopke mud than the loss in bagasse alone when settling were returned to the mill. It should be noted in this connection that grinding rates are higher than when the straight Petree process was in use, tending to increase the loss in bagasse, and that when the mud was returned to the mill the increased weight of bagasse due to solids thus added was not taken into consideration in calculating the loss of sucrose in bagasse. Both of these factors tend to decrease the difference noted above.

Now that the loss in press cake has reached a half of one per cent of the total sucrose in the cane, it deserves serious attention. In the writer's opinion, an adequate solution of this problem is not so much increasing capacities along present lines as it is finding equipment capable of performing this operation efficiently.

*Evaporation:* The Brix of the syrup has increased from 63.65 to 64.04, the highest figure on record. During the past few seasons calculations based on mixed juice and syrup densities have indicated a consistent increase in the amount of water evaporated per hour. The increase over last season is 2.6 per cent.

*Commercial Sugar:* The commercial sugar is higher in polarization. This year's average, 97.30, is the highest since 1911. While figures in the larger table indicate an increase of .08 in polarization, calculated to a basis comparable with 1925, the increase is .12. Moisture in the sugar has decreased in greater proportion than the increase in polarization, reducing the deterioration factor to .251. This is the first time that the average deterioration factor has been reduced to this point. The increase in commercial sugar polarization accounts for approximately .04 of the decrease in recovery.

*Low Grade Work:* The combined effect of higher grinding rate, lower syrup purity and higher polarizing sugar, has been an increase of slightly over seven per cent in the duty imposed on the low grade equipment. Twenty-one out of thirty-seven factories report higher molasses purity this year. The average purity has increased .65. As noted in a previous paragraph, the change in the method for determining sucrose in molasses has reduced the gravity purity by .6 in comparison with figures for years prior to 1925. This year's average, allowing for this difference, is higher than previous averages since 1922. The weight of molasses per cent cane is greater than in 1924 and 1925, as is also the loss per cent polarization in the cane.

No factory has equaled the record of 32.46 for gravity purity of molasses made by Kahuku in 1925.

#### RECOVERY

The following comments all refer to figures calculated to a basis comparable with last year, where these figures differ from averages in the large table. The first expressed juice purity is .47 lower than last season. Smaller decreases from first expressed to mixed juice and larger increases from mixed juice to syrup, however, have reduced the difference between syrup purities in the two seasons to .37.

Boiling house recovery has decreased from 91.59 to 91.03 and recovery per cent polarization in cane from 89.11 to 88.53; decreases of .56 and .58 respectively. The increase in sugar polarization corresponds to a decrease of approximately .04 in recovery, so on the basis of recovery of available sugar we may consider the decrease .54 instead of .58. The decrease in recovery corresponding to lower initial purity amounts to slightly over one-half the decrease. Higher molasses purity is the next largest factor. Indirectly, a considerable part of this increase in molasses purity may be credited also to lower juice purity, this factor materially increasing the duty imposed on low grade equipment. Other factors tending toward lower recovery are increased loss in press cake and lower extraction. Partially offsetting these factors are a smaller decrease in purity at the mill, a larger purity increase in clarification, and a slightly better recovery on available. So far as can be inferred from these data, slightly less than one-half of the decrease in recovery is attributable to results secured in manufacture, while lower initial purities correspond to slightly more than one-half of the decrease.

This conclusion is closely confirmed by data for quality ratio and tons of cane required to make a ton of sugar. These figures, with corresponding figures for yield per cent cane, carried to the third decimal place, follow:

	Tons Cane Per Ton Sugar Quality Ratio	Tons Per Ton Sugar	Theoretical Yield Per Cent Cane	Actual Yield Per Cent Cane
1925 .....	8.277	8.266	12.082	12.098
1926 .....	8.305	8.313	12.041	12.029
Difference .....			.041	.069

The decrease in yield of sugar per cent cane, corresponding to the change in quality ratio, is .041, while the actual decrease in yield of commercial sugar is .069. On this basis also we have an indication that somewhat more than one-half of the decrease in recovery is attributable to poorer quality of cane and somewhat less than one-half to manufacturing operations.

#### ACTUAL AND THEORETICAL RECOVERIES

Comparisons of actual and theoretical recoveries calculated on the basis of 100 per cent extraction, 37.5 gravity purity molasses and no other losses, are in Table 9. As this table has been the subject of considerable comment and criticism, a discussion of these calculations and reasons for continuing this table in the Synopsis seems desirable. It was first presented in the Synopsis under the title "Factory Efficiency," the term efficiency referring to the proportion of the available sugar in the cane actually recovered. Later it was recognized that these calculations did not give sufficiently consistent results to merit the term efficiency. The title was then changed to "Comparisons of Actual and Calculated Recovery," and the table presented with the comment that these data should be considered approximate rather than exact.

One defect in these calculations is that the relative standing is influenced by juice purities. If, for instance, the standard for molasses purity is lower than the purity attained in practice, factories with low juice purities will be ranked lower than the quality of the work warrants. The influence of this factor can be reduced to a minimum, though not eliminated, by taking average performance as the standard. Originally the standard for molasses purity was lower than that attained in practice. This was later changed to 37.5 purity, a figure approximating the average. While basing the standard on average performance results in figures of over 100 per cent in many instances, the writer does not consider this a material objection. As variations in cane fiber have an influence similar to variations in juice purity, average performance would be preferable as the standard for extraction. This change has not been made so far, partly because in most cases the influence of this factor is not large, and also because of the uncertainty as to how the purity of the mixed juice should be calculated at a given extraction other than 100 per cent. At 100 per cent extraction, mixed juice purity is assumed to be that of the normal juice. Another factor influencing the consistency of these calculations is the purity to which the molasses can be reduced with a given efficiency of low grade work. From experimental work at this Station and observations at

TABLE NO. 9

## COMPARISON OF ACTUAL AND CALCULATED RECOVERIES

The factories are arranged in the order of the ratio of their recovery to that resulting from 100% extraction, reducing the molasses to 37.5 gravity purity, and eliminating all other losses. Factories reporting a recovery of over 101% of the available (Table No. 4) are omitted from this tabulation.

No.	Factory	Milling	Boiling House	Over All
1	Hakalau .....	98.88	101.56	100.56
2	Onomea .....	98.72	100.92	99.90
3	Ewa .....	98.00	101.07	99.39
4	Wailuku .....	98.48	100.03	98.74
5	Pepeekeo .....	97.82	100.83	98.74
6	Honomu .....	98.12	100.29	98.68
7	Pioneer .....	97.52	100.64	98.63
8	Waimanalo .....	98.56	99.78	98.57
9	Hilo .....	98.19	99.75	98.21
10	Lihue .....	96.82	100.98	98.20
11	Kekaha .....	98.45	99.20	98.02
12	Paauhau .....	97.47	100.16	97.93
13	Haw. Sug.....	97.56	100.06	97.82
14	Waialua .....	97.17	99.88	97.46
15	Oahu .....	97.51	99.56	97.41
16	Kilauea .....	97.27	99.43	97.19
17	Koloa .....	96.78	99.75	97.12
18	Maui Agr.....	95.94	100.15	96.70
19	H. C. & S. Co.....	97.89	98.28	96.43
20	McBryde .....	97.16	98.96	96.43
21	Honokaa .....	95.72	100.04	96.25
22	Kohala .....	97.14	98.59	96.16
23	Hamakua .....	97.15	98.44	96.04
24	Laupahoehoe .....	97.10	97.97	95.37
25	Haw. Agr.....	96.82	98.20	95.37
26	Olaa .....	96.88	97.91	95.28
27	Makee .....	96.07	98.67	95.18
28	Hawi .....	96.39	97.15	94.04
29	Kaiwiki .....	96.14	96.96	93.54
30	Waimea .....	96.69	96.07	93.26
31	Hutchinson .....	95.76	96.84	93.12
32	Waiakea .....	95.37	97.07	93.04
33	Olowalu .....	97.62	94.48	92.61
34	Halawa .....	93.66	97.53	91.72
35	Union Mill .....	94.45	96.32	91.28
36	Niulii .....	93.28	96.99	90.91
37	Kaeleku .....	95.07	94.34	90.06
38	Waianae .....	95.86	92.92	89.46

some of the factories, it would seem that a variation of three in gravity purity should be about the maximum influence of this factor. After studying these figures for a number of years, it is the writer's opinion that the maximum total discrepancy due to these factors is not likely to exceed two in the third column of the table. Efficiency of clarification is not a factor in these calculations, no equitable method for evaluating this on a percentage basis having come to the writer's attention.

Some of the criticisms of this table have been that no allowance is made for difference in available equipment. Making allowances for the efficiency of equipment as suggested, involves estimating what should be expected of the equipment at each factory. While statistics published in Annual Synopses, considered in relation to conditions at a particular factory, should furnish a basis for estimating how efficiently equipment has been operated, the writer considers that attempting this for all factories is beyond the scope of the Synopsis.

Another criticism is that greater weight is frequently given the ranking indicated in this table than is justified by its accuracy. Without doubt, too literal an interpretation is frequently placed on data in this table, notwithstanding accompanying comments on the accuracy of the figures. This seems due to a widespread tendency to base inference as to the extent to which the available sugar in the cane has been recovered on some single figure. No method for calculating such a figure that has come to the writer's notice is free from defects. Such figures are valuable if used with due allowance for their probable accuracy, but the fact must be kept in mind that the reliability of conclusions based on them is limited. The writer does not wish to infer that reliable estimates of how closely the recovery approximates that possible with present processes cannot be made. On the contrary, given accurate control data, the writer believes that this can be quite closely estimated. Such estimates, however, involve the careful analysis of all available control data with due attention to factors such as those discussed under Chemical Control. The various factors involved are not readily expressed as a mathematical formula, and this has not been successfully accomplished in any formula that has come to the writer's notice.

Table 9 has been continued in the Synopsis because it serves a useful purpose in summarizing data submitted for the Synopsis and assigning an approximate standing to individual factories on the basis of the efficiency with which available sugar in the cane is recovered. While the factories are grouped substantially according to the quality of the results secured and a good general idea of the relative quality of work is conveyed, the ranking is hardly consistent enough to serve as a basis for close distinctions. If closer comparisons are desired, they must be based on analysis of all available control data. The writer trusts that this explanation will make the significance of this table clear.

The usual summary of losses is in Table 10.

Calculations in this Synopsis have been made by Mr. A. Brodie.

TABLE NO. 10  
SUMMARY OF LOSSES

FACTORY		POUNDS POLARIZATION PER TON OF CANE		POUNDS POLARIZATION PER 100 CANE		POLARIZATION PER 100 PAPER		FACTORY									
Presses	Cake	Moldless	Total	Presses	Cake	Moldless	Total	Presses	Cake								
H. C. & S. Co... Oahu.....	6.2 7.0	2.6 2.0	19.0 16.2	1.8 4.0	29.6 29.2	0.31 0.35	0.13 0.10	0.95 0.81	0.09 0.20	1.48 1.46	2.11 2.49	0.87 0.72	6.43 5.84	0.62 0.72	10.03 10.49	88.03 86.59	H. C. & S. Co.
Ewa.....	5.2 1.0	1.0 19.6	0.2 20.4	26.0 30.6	0.26 0.39	0.05 0.06	0.98 1.02	0.01 0.05	1.30 1.53	2.00 2.83	0.41 0.44	7.60 7.44	0.08 0.66	10.09 10.43	84.52 85.6	Ewa,	
Waihau.....	7.8 1.2	1.2 17.6	1.0 1.8	27.6 32.8	0.36 0.41	0.05 0.11	0.88 1.09	0.05 0.03	1.38 1.64	2.48 3.12	0.66 0.81	7.44 8.27	0.43 0.36	11.14 12.46	85.6 86.6	Waihau	
Pioneer.....	7.2 8.2	1.8 2.2	1.0 0.6	32.8 34.2*	0.41 0.62	0.11 0.11	0.99 0.95	0.03 0.05	1.09 1.26	3.12 4.06	0.66 0.66	9.56 12.46	0.36 0.26	11.14 12.46	85.6 86.6	Pioneer	
Olas.....	8.2 12.4	2.2 1.0	19.0 25.2	0.6 2.0	32.8 25.2	0.36 0.36	0.05 0.05	1.11 1.11	0.02 0.02	1.11 1.26	7.23 2.44	0.81 0.37	11.51* 6.48	—0.11 —0.67	87.60 88.34	Olas	
Maui Agr.....	7.2 7.2	1.0 1.0	18.2 25.2	0.6 2.6	30.6 25.2	0.40 0.40	0.09 0.09	0.91 0.91	0.13 0.13	1.53 1.53	3.18 3.18	0.72 0.72	12.23 7.29	1.04 1.04	86.28 83.7	Haw. Sug.	
Haw. Sug.....	8.0 3.0	1.8 0.4	18.2 16.4	0.4 0.4	30.6 25.2	0.40 0.22	0.09 0.04	0.82 0.89	0.02 0.11	1.01 1.26	1.28 1.81	0.28 0.29	8.36 7.31	10.34 10.93	86.28 85.73	Lihue, Onomea	
Lihue.....	4.4 7.8	0.8 1.2	17.8 24.6	2.2 2.2	30.6 24.6	0.22 0.39	0.05 0.06	1.23 1.23	0.04 0.06	1.26 1.23	2.73 2.73	0.44 0.44	8.74 8.74	10.34 10.34	86.57 86.57	Hilo	
Onomea.....	7.6 7.6	1.0 1.0	20.6 21.6	2.6 2.4	31.8 30.0	0.38 0.21	0.05 0.09	0.99 1.08	0.13 0.12	1.59 1.50	3.18 1.55	0.66 0.65	8.62 8.03	1.04 0.88	85.29 84.9	Honolulu	
Honolulu.....	7.6 4.2	1.8 0.4	21.6 16.0	2.4 1.0	30.0 25.2	0.21 0.14	0.09 0.02	0.99 0.97	0.12 0.05	1.50 1.01	1.55 1.12	0.65 0.52	8.03 6.52	11.11 11.11	84.9 84.9	Honolulu	
Kahala.....	2.8 4.2	0.4 0.4	19.4 20.6	0.2 0.2	25.2 25.2	0.21 0.15	0.07 0.02	0.98 0.82	0.01 0.02	1.26 1.01	1.52 1.28	0.51 0.51	6.81 6.76	0.04 0.04	86.8 86.8	Kahala	
Hakalau.....	4.2 4.2	1.2 1.2	24.2 24.2	1.8 1.8	36.6 36.6	0.47 0.47	0.06 0.06	1.21 1.21	0.09 0.09	1.83 1.83	3.93 3.93	0.49 0.49	10.17 10.17	0.73 0.73	15.32* 15.32*	Hakalau	
Waialuku.....	9.4 7.6	1.2 0.6	23.0 23.0	1.6 1.6	32.0 30.8	0.38 0.38	0.03 0.03	1.15 1.15	0.08 0.08	1.64 1.64	2.84 2.84	0.25 0.25	8.56 8.56	0.59 0.59	12.24 12.24	Pepeekeo	
Maake.....	9.4 7.6	1.2 0.6	23.0 19.6	1.6 0.2	30.8 29.0	0.49 0.38	0.06 0.04	0.98 0.88	0.01 0.01	1.54 1.45	4.28 2.90	0.56 0.33	8.65 6.83	0.09 0.33	13.58 13.58	Waialuku	
McBryde.....	9.8 7.6	0.6 0.8	19.6 17.6	0.2 1.2	29.0 39.2	0.49 0.38	0.06 0.04	0.98 0.88	0.01 0.01	1.54 1.45	2.90 2.90	0.56 0.33	8.65 6.83	0.09 0.33	13.58 13.58	Waialuku	
Honokaa.....	9.8 7.6	0.6 0.8	19.6 17.6	0.2 1.2	29.0 39.2	0.49 0.38	0.06 0.04	0.98 0.88	0.01 0.01	1.54 1.45	2.90 2.90	0.56 0.33	8.65 6.83	0.09 0.33	13.58 13.58	Waialuku	
Laupahoehoe.....	7.6 7.6	1.2 1.2	24.4 21.0	1.2 1.2	30.0 32.8	0.38 0.38	0.05 0.05	1.05 1.05	0.06 0.06	1.49 1.49	2.85 2.85	0.46 0.46	9.17 7.76	0.41 0.41	11.21 11.21	Waialuku	
Hanakua.....	7.6 6.4	1.2 0.6	24.4 14.4	1.8 1.8	32.8 22.2	0.38 0.27	0.03 0.03	1.05 0.72	0.09 0.09	1.11 1.11	2.18 2.18	0.21 0.21	8.17 5.77	0.39 0.73	85.1 86.8	Waialuku	
Pepeekeo.....	6.2 6.2	0.8 0.8	22.2 22.2	—2.2 —2.2	30.0 25.6	0.31 0.31	0.04 0.04	1.11 1.11	—0.11 —0.11	1.35 1.35	2.59 2.59	0.34 0.34	9.15 9.15	—0.94 —0.94	11.14 11.14	Pepeekeo	
Kahuku.....	6.2 6.2	0.4 0.4	18.0 18.0	1.0 1.0	25.6 24.2	0.31 0.24	0.02 0.03	0.90 0.89	0.05 0.05	1.28 1.21	2.53 1.98	0.15 0.26	7.29 7.08	0.42 0.40	10.39 10.39	83.2 85.76	Kahuku
Pauhau.....	4.8 8.0	0.6 2.6	17.8 22.0	1.0 1.4	24.2 34.2	0.24 0.40	0.03 0.13	0.93 0.92	0.05 0.06	1.21 1.10	1.88 1.70	0.26 0.07	7.08 1.03	0.40 0.38	10.39 20.88	81.50 81.98	Pauhau
Honolulu.....	4.8 8.0	0.6 2.6	17.8 22.0	1.0 1.4	24.2 34.2	0.24 0.40	0.03 0.13	0.93 0.92	0.05 0.06	1.21 1.10	1.88 1.70	0.26 0.07	7.08 1.03	0.40 0.38	10.39 20.88	81.50 81.98	Honolulu
Koloa.....	12.4 10.2	1.2 1.6	24.4 24.6	1.2 1.8	32.0 22.2	0.62 0.51	0.06 0.08	1.06 1.23	0.05 0.05	1.06 1.05	2.86 1.87	0.46 0.37	9.17 7.76	0.41 0.41	11.14 11.14	86.78 86.78	Koloa
Waiakea.....	12.4 10.2	1.2 1.6	24.4 24.6	1.2 1.8	32.0 22.2	0.62 0.51	0.06 0.08	1.06 1.23	0.05 0.05	1.06 1.05	2.86 1.87	0.46 0.37	9.17 7.76	0.41 0.41	11.14 11.14	86.78 86.78	Waiakea
Hutchinson.....	10.2 9.6	1.2 0.8	24.6 21.6	1.0 1.0	32.0 39.4	0.51 0.48	0.04 0.04	1.08 1.08	0.03 0.03	1.07 1.07	2.86 1.87	0.46 0.37	10.32 8.18	0.45 0.29	15.65 14.88	85.0 84.64	Hutchinson
Hawai.....	10.4 10.8	1.3 2.3	18.8 19.0	3.6 1.4	34.6 31.2	0.52 0.40	0.09 0.14	0.94 0.95	0.18 0.14	1.73 2.12	3.85 2.71	0.68 0.44	9.15 4.14	1.35 0.38	12.86 12.86	87.92 87.92	Hawai
Watnane.....	8.0 10.8	2.3 1.8	19.0 19.0	1.4 1.4	34.2 31.2	0.54 0.40	0.05 0.14	0.95 0.95	0.07 0.07	1.21 1.16	2.86 2.73	0.99 0.95	6.83 5.75	0.46 0.46	16.36 11.41	81.98 11.14	Watnane
Kohala.....	8.0 11.6	1.2 2.4	19.0 28.0	1.0 1.0	34.2 39.4	0.54 0.51	0.05 0.08	0.95 0.98	0.07 0.07	1.21 1.27	2.86 2.73	0.99 0.95	6.83 5.75	0.46 0.46	16.36 11.41	81.98 11.14	Kohala
Kihisea.....	6.0 8.4	2.2 2.4	25.4 28.0	3.2 7.0	36.8 49.0	0.30 0.58	0.11 0.12	1.27 1.40	0.06 0.10	1.16 1.06	1.84 1.38	0.46 0.37	9.17 8.98	0.44 0.38	14.72 14.88	83.41 84.64	Kihisea
Waimanao.....	6.0 11.6	2.2 2.4	25.4 28.0	3.2 7.0	36.8 49.0	0.30 0.58	0.11 0.12	1.27 1.40	0.06 0.10	1.16 1.06	1.84 1.38	0.46 0.37	9.17 8.98	0.44 0.38	14.72 14.88	83.41 84.64	Waimanao
Kaeleku.....	10.4 13.8	1.3 2.2	18.8 23.0	3.6 5.0	34.6 40.0	0.52 0.69	0.09 0.11	1.08 1.15	0.35 0.25	1.73 2.11	3.85 6.34	0.68 0.87	9.15 9.20	0.38 0.38	16.00 16.00	86.3 86.3	Kaeleku
Union Mill.....	16.0 17.0	1.2 1.3	16.0 17.0	4.2 4.1	42.4 41.0	0.54 0.44	0.05 0.06	0.95 0.98	0.07 0.08	1.21 1.20	2.86 2.73	0.99 0.95	6.83 5.75	0.46 0.46	16.75 16.75	85.5 85.5	Union Mill
Halawa.....	8.8 17.0	1.6 1.2	16.0 17.0	3.6 1.6	30.6 25.6	0.40 0.85	0.06 0.06	1.04 1.28	0.05 0.07	1.05 1.29	2.86 2.29	0.99 0.95	6.83 5.75	0.46 0.46	16.75 16.75	85.5 85.5	Halawa
Waimea.....	8.8 17.0	1.6 1.2	16.0 17.0	3.6 1.6	30.6 25.6	0.40 0.85	0.06 0.06	1.04 1.28	0.05 0.07	1.05 1.29	2.86 2.29	0.99 0.95	6.83 5.75	0.46 0.46	16.75 16.75	85.5 85.5	Waimea
Niuifi.....	16.6 16.6	1.6 1.6	18.8 18.8	1.6 1.6	34.2 44.4	0.33 0.33	0.08 0.08	0.94 0.94	0.08 0.08	1.04 1.04	2.38 2.22	0.56 0.56	6.73 6.17	0.06 0.06	17.25 17.25	85.10 84.9	Niuifi
Olowalu.....	16.6 16.6	1.6 1.6	18.8 18.8	1.6 1.6	34.2 44.4	0.33 0.33	0.08 0.08	0.94 0.94	0.08 0.08	1.04 1.04	2.38 2.22	0.56 0.56	6.73 6.17	0.06 0.06	17.25 17.25	85.10 84.9	Olowalu

\* Sucrose.



## Sugar Prices

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**96° Centrifugals for the Period  
September 20 to December 13, 1926**

Date	Per Pound	Per Ton	Remarks
Sept. 20, 1926.....	4.52¢	\$ 90.40	Cubas.
" 23.....	4.535	90.70	Cubas, 4.55; Porto Ricos, 4.52.
" 24.....	4.52	90.40	Cubas.
" 28.....	4.63	92.60	Philippines, 4.61; Cubas, 4.65.
" 29.....	4.65	93.00	Spot Cubas.
Oct. 4,.....	4.61	92.20	Cubas.
" 7.....	4.65	93.00	Cubas.
" 11.....	4.58	91.60	Cubas.
" 14.....	4.55	91.00	Cubas, 4.52, 4.58.
" 20.....	4.52	90.40	Cubas.
" 22.....	4.58	91.60	Cubas.
" 26.....	4.52	90.40	Cubas.
Nov. 4.....	4.58	91.60	Cubas.
" 11.....	4.55	91.00	Cubas.
" 12.....	4.58	91.60	Cubas.
" 17.....	4.61	92.20	Cubas.
" 18.....	4.71	94.20	Cubas, 4.65, 4.77.
" 19.....	4.83	96.60	Cubas.
" 20.....	4.865	97.30	Cubas, 4.83, 4.90.
" 22.....	4.90	98.00	Cubas.
Dec. 2.....	5.01	100.20	— 5.02, 5.00.
" 3.....	5.02	100.40	Cubas.
" 6.....	5.15	103.00	Porto Ricos.
" 8.....	5.08	101.60	Cubas.
" 13.....	5.15	103.00	Cubas.

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# THE HAWAIIAN PLANTERS' RECORD

Volume XXXI.

APRIL, 1927

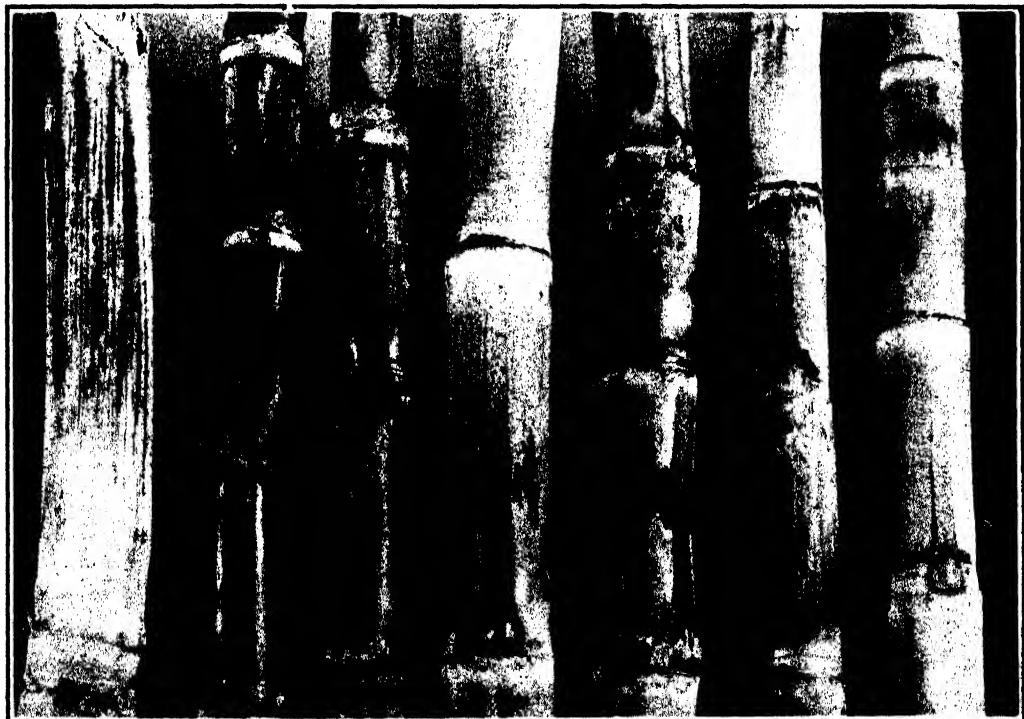
Number 2

*A quarterly paper devoted to the sugar interests of Hawaii and issued by the Experiment Station for circulation among the Plantations of the Hawaiian Sugar Planters' Association.*

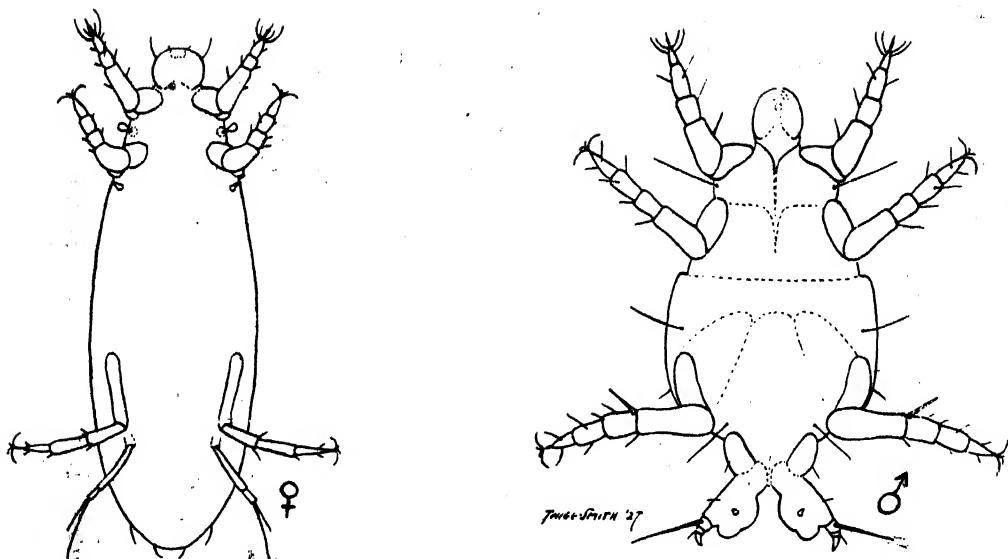
## The Java Sugar Cane Stalk Mite in Hawaii

By O. H. SWEZEY

It is not known how long this minute mite has been in the cane fields of Hawaii. The mite itself is seldom seen, but the appearance of the cane that has been infested with mites persists indefinitely, so that their presence in a field



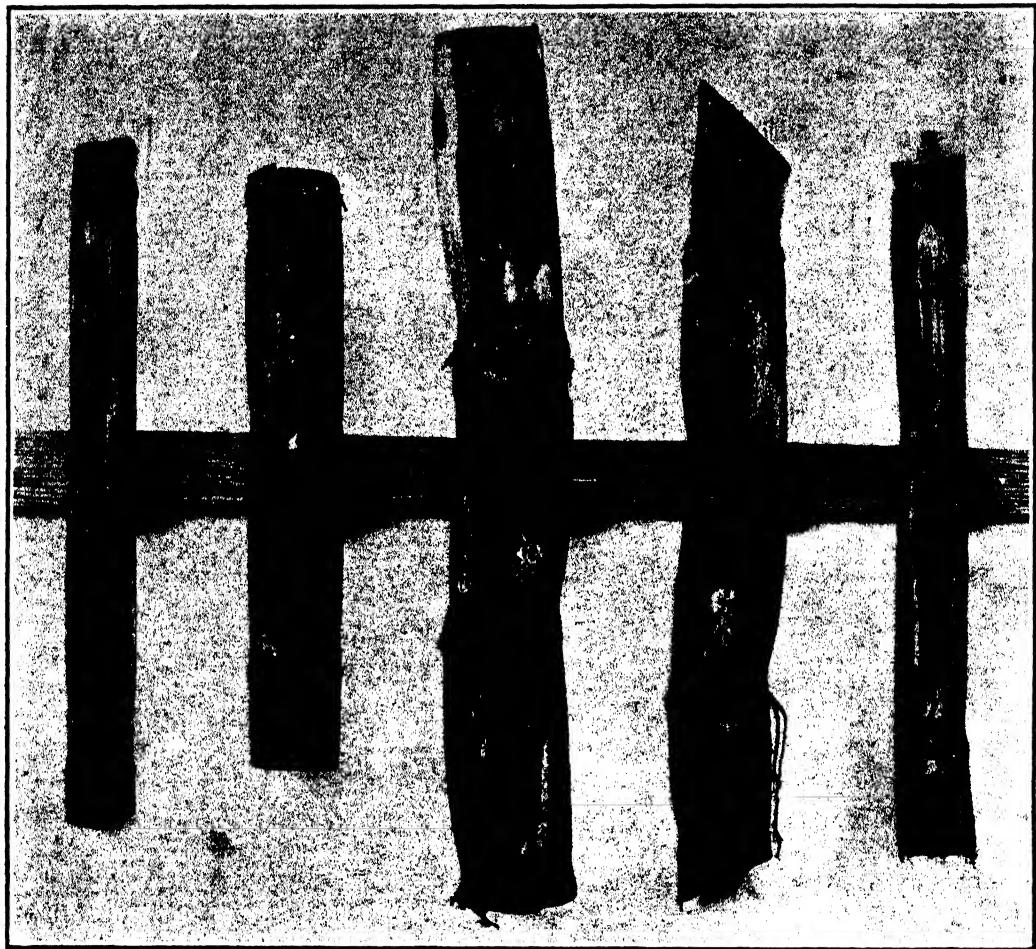
*Tarsonemus bancrofti.* The dark patches and markings on the canes are due to the rusty, dried remains of vesicles caused by the mites when the canes were soft in an earlier stage of their growth. Note that there is commonly a streak above the bud. At the extreme left are shown these same rusty streaks on the outside of a leafsheath. They sometimes occur similarly on the blade of the leaf near the base. (About half natural size.)



*Tarsonemus bancrofti*. Female mite at the left. Male mite at the right. (Both highly enlarged.)

is thereby made known. The illustration shows the characteristic appearance of a cane stalk where the mites have lived at an earlier stage in the growth of the cane. This rusty appearance of the stalk is due to the shrivelled up and dried galls that were produced when the mites were feeding there. This occurred when the stalk was very soft and still growing, closely enclosed in the green leafsheaths of the upper leaves of the stalk.

The mites are minute, microscopic white forms, and it is rather difficult to understand how they gain access to the places where found in the closely rolled leafsheaths of the growing cane spindle. By their feeding, minute globular pustules or galls are formed on the surface of the rind. It is not unusual for mites to produce abnormal growths on the plants on which they feed. There are many species that produce galls on leaves, and aborted inflorescence, or excessive growths of the flower parts may occur when fed on by the mites. The leaves of the litchi tree are sometimes affected. Examples of abnormal structures caused by mites are found on several native Hawaiian trees, as: *Broussaisia*, *Perrottetia*, *Euphorbia*, *Elaeocarpus*, etc. Often it is very difficult to associate the mites with the injury that they do, for the mites are so small and so hard to find, and often have caused or started the injury and have left it before it has advanced to the stage of being noticeable, so that when the examination is being made often no traces of them are to be found. As in the case of the sugar cane stalk mite, none is to be found in the rusty streaks of the dried remains of the galls on the stalk after these have become exposed by the falling away of the leaves. To find the mites themselves, one has to tear apart the very upper part of the cane top where the stalk is soft and still growing, and then it is difficult to find them on account of their minute size, and, too, the galls that have been formed and among which the mites are, are almost unnoticeable, being so small and colorless. They do not show up conspicuously till they become discolored in the process of drying up.



Lesions of the cane that have occurred at the areas which had been severely infested by the stalk mite.

This mite is generally distributed in Java. Some account of it is given by Kruger in "Das Zuckerrhor und seine Kultur," pp. 320, 396, Tafel IX, Fig. 3, 1899, and by Van Deventer in "Handboek voor de Suikerriet-Cultur en de Rietsuiker-Fabricage op Java," Tweede Deel, pp. 292-293, Plate 40, Fig. 7, 1906. The name given is *Tarsonymus bancrofti* Michael. It is presumed that what we have in the cane fields in Hawaii is the same species on account of the similarity of the affected cane stalks. The mites themselves have not been compared. It is known in Queensland, Mauritius, Barbados, and, no doubt, occurs on cane throughout the Pacific area, though records are not at hand.

In Porto Rico a different species occurs, *Tarsonemus spinipes* Hirst, and called the cane rust-mite by Smyth (Porto Rico Department of Agriculture Journal, 3; 4, p. 92, 1919). This is unquestionably not the species we have in Hawaii, for it is said to occur especially on Yellow Caledonia cane (Wolcott, Journ. Dept. Agr. Porto Rico, V, No. II, p. 10, 1921), whereas the stalk mite here in Hawaii is seldom found on this variety of cane. Apparently nearly all other varieties are susceptible to its attack.

Usually no appreciable injury is caused by this mite in Hawaii, though its excessive prevalence at times would indicate that there must be some check to the full growth of the cane. Instead of merely a rusty streak on the stalk extending upward from the bud and reaching to, or nearly to the next node, sometimes there are others of these rusty streaks more or less all around the stalk, and also areas continuous around the stalk at the nodes. There may also be similar rusty streaks on the leafsheaths and even on the blade of the leaf.

There have been instances where splitting of the cane stalk has occurred at the rusty streaks above the eyes, and sometimes accompanied by rotting of the stalk at this place. These have been infrequent, however, and occurring when other causes or conditions contributed in bringing about the damage. (See illustration.)

The fact that this mite is so generally and continuously spread in Hawaiian cane fields, suggests that it must be carried on the seed. This could readily be accounted for by the fact that the general practice is to use the top cutting from the stalk for planting. This would be just where there would likely be some of the mites lurking about the uppermost nodes, or eyes, or beneath any portion of leafsheath that might remain. In general, since there is no important injury done, there is no need to try to control this pest. It is reported that in Queensland, dilute carbolic acid and also lime water have been used for disinfecting the cuttings, but probably this practice is not much used.

## The Bad Effect of Leaf Pruning Upon the Growth of Stalk and Root of Sugar Cane

BY F. MUIR AND R. H. VAN ZWALUWENBURG

In the study of root rot in sugar cane it has been necessary to separate the various factors which inhibit the growth of roots or cause their decay after their growth. Among these factors is the pruning of the leaves, either by artificial cutting of the leaves or by death caused by insect or fungus attack. The bad effect of such pruning upon the growth of the stalk has long been recognized but its effect upon the roots has not been given so much attention, although it is equally marked. The bad effect was to be anticipated as the reduction of leaf surface reduces the amount of the manufactured substances necessary for the building up of roots and stalks. Figs. 1 and 2 illustrate the effect very plainly.

The cane was planted at Alexander Street, June 25, 1926, from three sticks of H 109 cut from one stool. The seed pieces used were of approximate length and diameter. The rows received usual irrigation, but no fertilization. After three months one-half of the row was leaf pruned, leaving only the two uppermost leaves; this pruning was repeated thereafter at intervals averaging about twelve days. The canes were harvested and the accompanying illustrations were



Fig. 1. 1, 2 and 3 are three stools of plant H 109 eight months old which were leaf pruned from the third month of growth at intervals of about twelve days. 4 is a stool of plant H 109 of same age that was not leaf pruned.

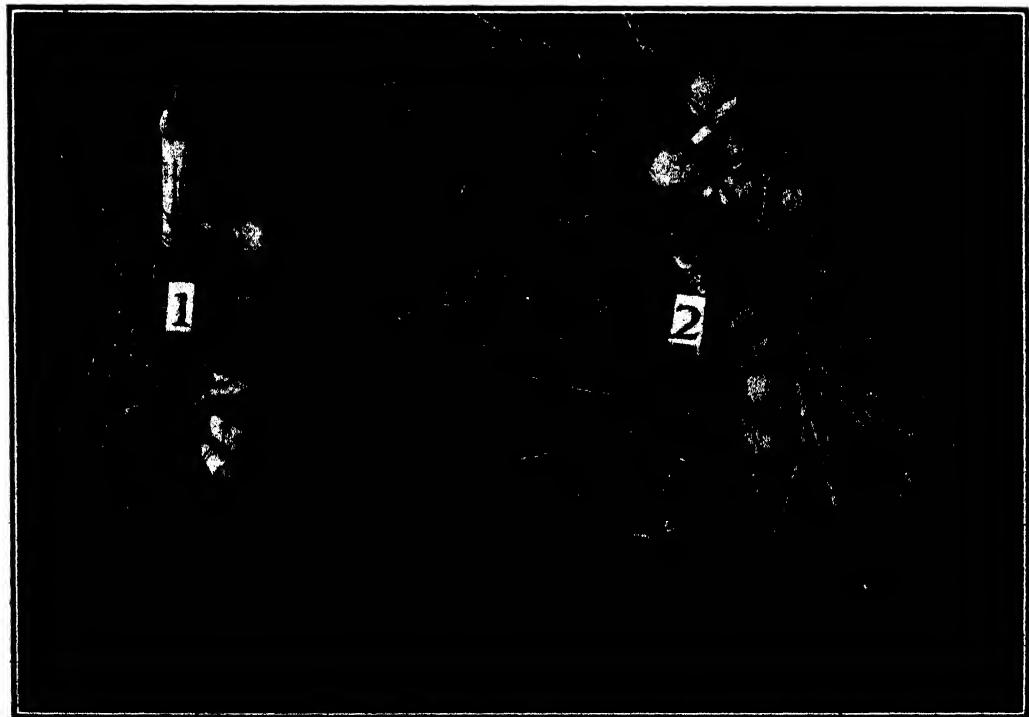


Fig. 2. 1. The root of stool No. 1 in Fig. 1. 2. The root of an unpruned stool.

taken February 4, 1927. At no time during the experiment were leafhoppers numerous, or was any leaf disease noticed.

During severe leafhopper attacks in the past it was noticed that the plants often had a poor root system and it was suggested that the plants were naturally weak on this account and therefore more susceptible to leafhopper attack than they would be if in a healthy condition. From the above experiment it is more likely that the roots were reduced by the death of the leaves due to leafhopper attack. Again, it was noticed that plant cane badly attacked by leafhopper gave poor ratoons even when the ratoons were not attacked. This is also understandable when we compare the stools in Fig. 2.

A similar condition is sometimes found to exist during bad eye spot attack, and here again it is suggested that a weak root system predisposes the plant to the fungus attack. We would suggest the reverse of this, as in the case of leafhopper attack.

The experiment will be continued on the ratoons.

## The Effect of Heat on the Germination of Sugar Cane Cuttings

By J. A. VERRET

The object of this experiment was to determine the temperature which gives the best germination of sugar cane cuttings.

Electric ovens and the constant temperature room in the sugar technology building were used to obtain the desired temperatures.

Three three-eye cuttings were placed in large Petrie dishes and covered with soil. Water was then added to bring the soil moisture to 30 per cent on the dry basis.

The results obtained from this test are tabulated herewith:

### GERMINATION RATE

Temperature	No. of eyes planted	Days after planting							Total ger- minations	Per cent ger- minations	Avg. height of shoots on ninth day
		3	4	5	6	7	8	9			
68° F.	18*	..	..	..	..	..	..	..	..	..	0 c.m.
82° F.	36	..	3	..	3	5	4	4	19	53	4 c.m.
90° F.	18	..	..	..	..	..	3	2	5	28	5.5 c.m.
93° F.	18	1	3	5	2	..	..	..	11	61	9.0 c.m.
97° F.	54	1	9	5	14	3	..	1	33	61	11.0 c.m.
100° F.	18	..	..	6	5	1	..	..	12	67	10.5 c.m.
111° F.	18	..	4	..	..	..	..	..	4	22	4.5 c.m.

These data indicate that 68° F. is too cold and germination is greatly retarded, while 111° F. is too warm for good results.

The best temperature for rapid and high generation would seem to be between 92 to 100° F.

\* No germinations until the sixteenth day.

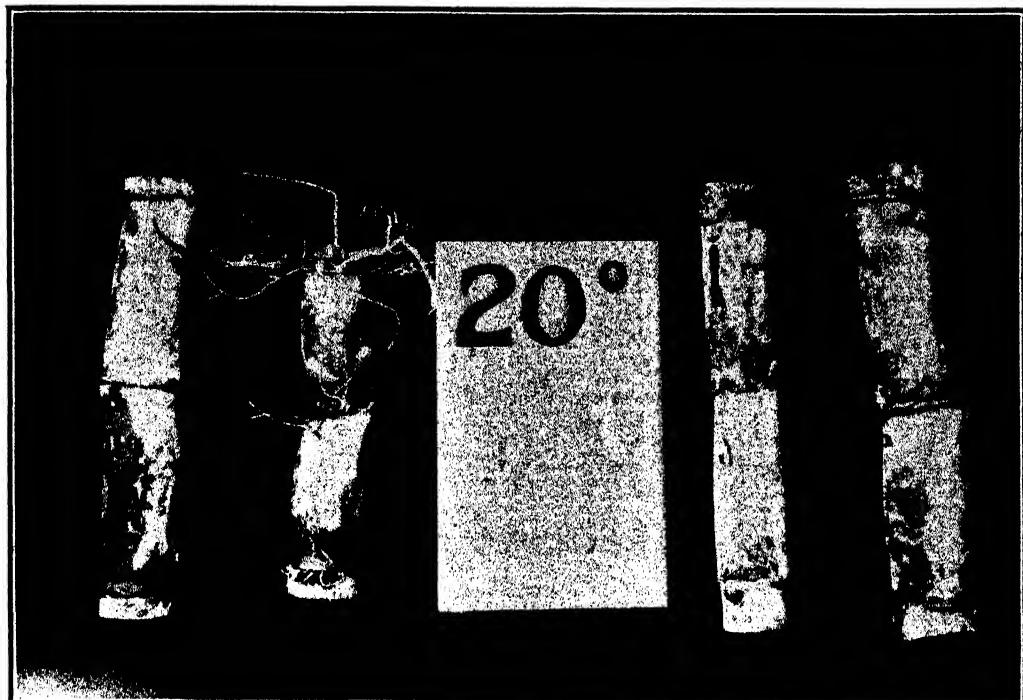


Fig. 1. These seed pieces were kept at a temperature of 68° F. Photographed sixteen days after planting. Compare with Figs. 3 and 4, and note the difference in growth.

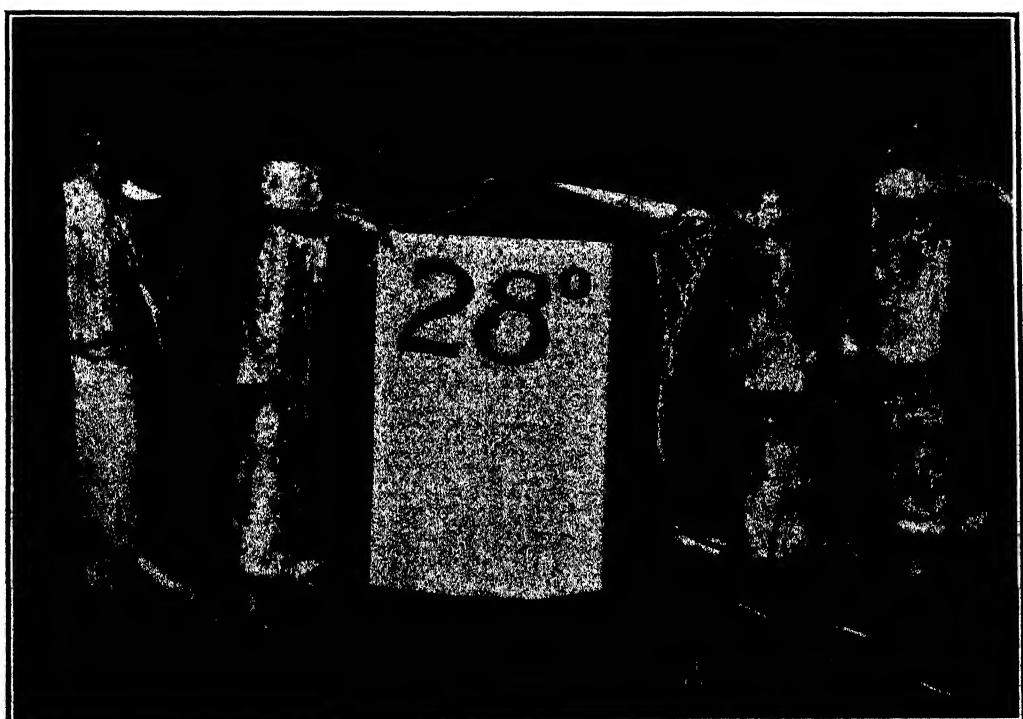


Fig. 2. Seed pieces kept at a temperature of 82° F. Photographed nine days after planting.



Fig. 3. Seed pieces were kept at a temperature of 90° F. Photographed nine days after planting.



Fig. 4. These seed pieces were kept at a temperature of 97° F. Photographed nine days after planting.



Fig. 5. Same as Fig. 4.

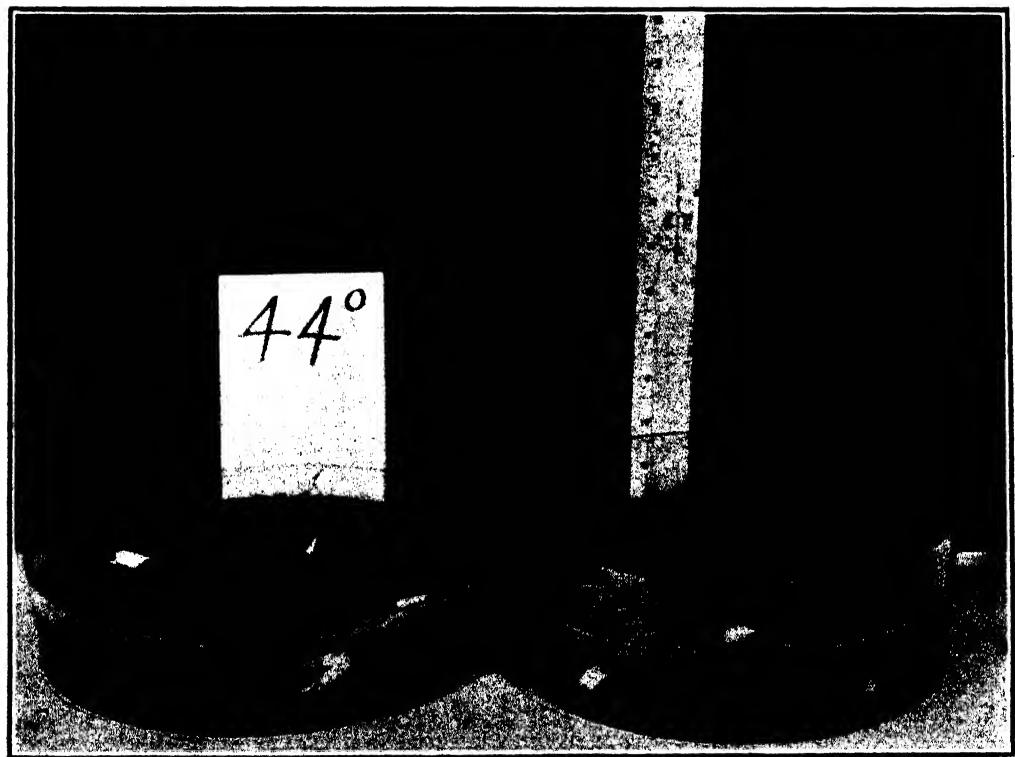


Fig. 6. Seed kept at a temperature of 111° F. Note the lack of growth as compared with Figs. 3, 4 and 5.

## The Effect of Sunlight on Cane Growth

BY J. A. VERRET AND R. H. MCLENNAN

This experiment was started under the supervision of Douglas A. Cooke. Upon leaving to continue his studies in Germany the work was transferred to R. H. McLennan.

The object of this experiment was to determine the effect of varying amounts of light on the growth and development of the sugar cane plant.

The plants were in 16" concrete pots. Twenty-four pots were used divided into 8 sets of 3 pots each. All treatments, such as irrigation, fertilization, etc., except light, were uniform to all pots.

The soil mixture used was made up of 5 parts well rotted cane leaf compost, 4 parts Makiki soil and 1 part of black sand. A three-eye cutting of H 109 from which the two end eyes had been gouged out, was planted in each pot. A large number of these seed pieces had been previously germinated in small trays. These seed pieces were as nearly alike in size and age as it was possible to make them and plants of exactly the same size were selected for planting in the pots.

Five sets of pots were kept continually covered with dark, thick, fairly thick, thin and very thin cages. The dark cage was made of roofing paper and all precautions taken to prevent entrance of light. The other four cages were covered with varying thicknesses of cloth. Of the other three sets, one was exposed to eight hours of sunlight, another to four hours, the rest of the time they were covered with dark cages; the third set was exposed for the entire twenty-four hours.

The set receiving eight hours sunlight was exposed from 8:00 a. m. to 4:00 p. m. The four-hour one from 8:00 a. m. to noon.

Weekly counts and measurements were made for six weeks.

The per cent of light admitted to the various cages was determined by exposing blue print paper to full sunlight, and in the cages, and noting the rate of change.

The data obtained are tabulated as follows:

Treatment	Per cent illumination	Total elongation for all shoots in inches	Total new shoots	Average temperature
Check .....	100	206	25	30.3
Exposed 8 hours.....	...	178	18	...
Very thin .....	42	173	12	31.8
Thin .....	12.7	88	6	32.3
Fairly thick .....	4	37	3	32.2
Exposed 4 hours.....	...	26	3	...
Thick .....	Less than 1	8	0	31.3
Dark .....	Less than 1	6*	0	31.2

\* The plant in one pot died at the end of four weeks. The plants in the other two pots were dying when the experiment stopped. (See Fig. 8.)

These data conclusively show that any lessening in normal illumination is detrimental to maximum sugar cane growth in June and July.

This is well shown in the illustrations, Figs. 1 to 8. The full sunlight canes had thicker stalks and broader, greener leaves, and the best stooling (Fig. 1). Next in order were the plants exposed to full sunlight from 8:00 a. m. to 4:00 p. m. (Fig. 2). In this set the leaves were not quite as sturdy as were the full sunlight ones.

In Fig. 3 is shown the set of plants which received 42 per cent of light, but no direct sunlight, as they were continually covered with a cage made of very thin muslin. This would about correspond to the light of a fairly cloudy day. Here we see at once a change in the character of growth. The plants tend to become long and slender. The leaves are thin and narrow with a distinct yellow color as compared to the dark green of the plants shown in Figs. 1 and 2.

In Fig. 4 we show the plants receiving 12.5 per cent of light coming through thin sheeting. Note how weak the leaves are from their broken condition, and the very poor stooling.

In the remaining sets there was practically no stooling and all the plants were very weak.



Fig. 1. These pots were entirely exposed. Note the stooling that results from the normal supply of sunlight.

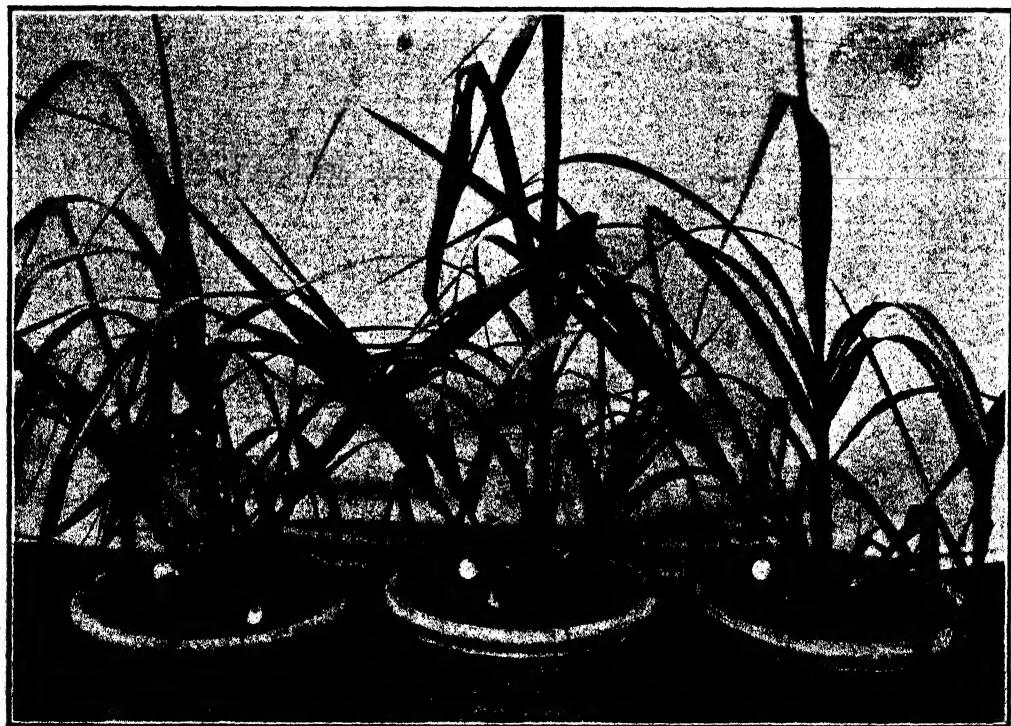


Fig. 2. The pots in this picture were exposed to sunlight daily for a period of eight hours from 8 a. m. to 4 p. m. A dark cage covers them from 4 p. m. to 8 a. m. This cage admits less than 1 per cent normal daylight. Compare stooling qualities with Fig. 1.



Fig. 3. These pots were covered day and night with a cage that admitted 41.67 per cent of normal illumination. Note the shoots and compare them with those in Fig. 1.



Fig. 4. A cage that admitted 12.50 per cent of normal illumination covers these three pots day and night. It would be well to note shoots in Figs. 1 and 3 and compare them.



Fig. 5. These pots were exposed daily to sunlight from 8 a. m. to 12 noon. The rest of the time they were covered with a dark cage, as in Fig. 2. Compare stooling qualities with Figs. 1 and 2.

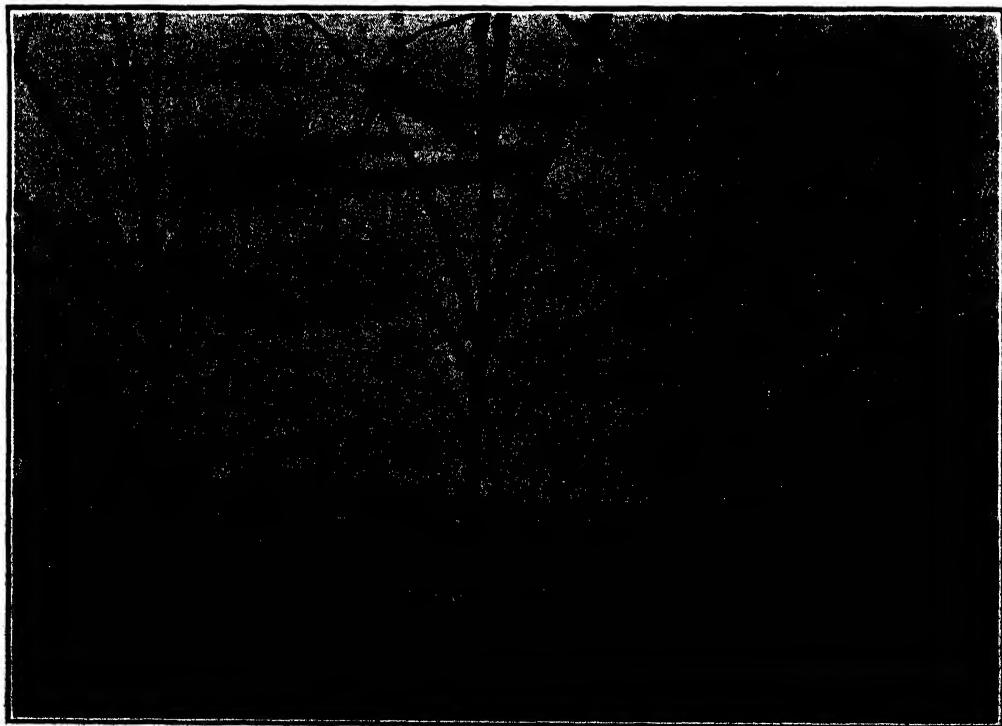


Fig. 6. These plants get 4.17 per cent of the normal daylight through the cage that covers them. Due to the lack of sunlight, very few shoots have grown. Note the stooling in the other pots, where more light is admitted.



Fig. 7. These plants received less than 1 per cent normal daylight, but more light than the pots in Fig. 8. Note the type of shoots developed due to the lack of light.

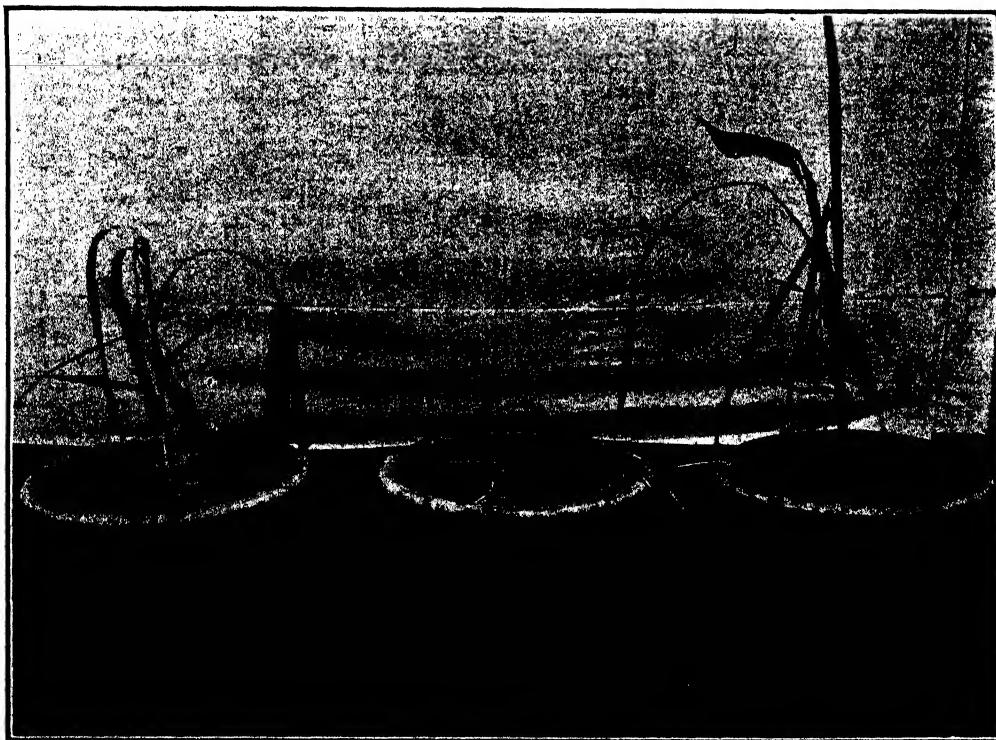


Fig. 8. The dark cage that covered these plants allowed less than 1 per cent of normal daylight to reach the plants. Compare this with Fig. 7. Note the droopy appearance of the leaves, due to the lack of photosynthesis taking place.

## Early Fertilization Gives Better Juices

PIONEER MILL COMPANY EXPERIMENT 56

By J. A. VERRET

The cane in this field was H 109, first ratoons, 21 months old when harvested on January 6, 1927.

The layout of this experiment comprised 28 watercourse plots of varying areas, each approximating 0.1 acre. We had seven repetitions of each treatment.

The fertilizer applications to these plots were as follows:

Plots	No. of Plots	June 1925				Sept., 1925				Nov. 1925		Feb. 1926		April 1926		Totals
		Amm.	Amm.	Acid	Pot.	Amm.	Sul.	Sul.	N. S.	N. S.	N.	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O			
		N	7	250	335	750	204	...	774	...	240	150	100			
O	7	250	335	750	204	385	...	...	...	240	150	100				
P	7	250	43	750	204	293	...	774	240	150	100					
Q	7	250	335	750	204	293	...	387	240	150	100					

The results obtained are given:

Plots	Treatment—Pounds Nitrogen					Tons per Acre		
	June 1925	Sept. 1925	Nov. 1925	Feb. 1926	April 1926	Cane	Q. R.	Sugar
O	50	70	120	0	0	77.3	8.31	9.08
N	50	70	...	120	0	74.7	8.74	8.54
Q	50	70	60	0	60	73.8	8.72	8.46
P	50	70	60	0	120	71.8	8.81	8.15

In this test the highest yields and the best juices were from the plots getting the earliest fertilization, while the lowest yields and the poorest juices were from the late fertilizer plots. The plots which received the "spring dressing" in November produced half a ton of sugar more than the plots receiving it four months later in February, and almost one more when this application was delayed to April.

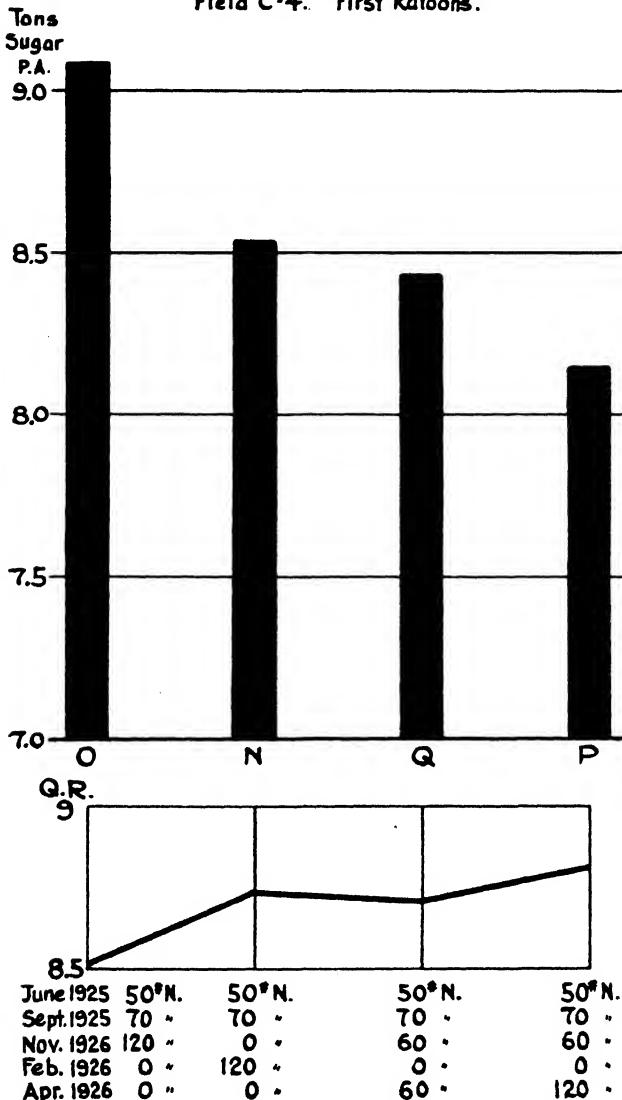
The yields show a gradual, steady decrease as fertilization is delayed, while the juices show the same steady decrease in quality.

We are very strongly convinced that we can very materially improve our juices and increase our yields of sugar by early, intensive fertilization. This means applying all the fertilizer within six months. By this system all fields harvested up to July would receive all their fertilization before the end of the year. This will naturally lead towards shorter cropping, as with the more intensive growth in the beginning the cane will obtain its growth more quickly than is now the case.

We also believe that this applies to the rainy districts as well as to the irrigated ones. Recent studies on the irrigated plantations show that cane up to six months receives from 4 to 6 acre inches of water per acre per irrigation. The irrigation intervals are about 20 days on an average. This amount of water is applied very rapidly and does not cover the entire surface of the ground.

The rainy districts get no such rains at 20-day intervals. So we do not believe that the plantations of heavy rainfall need fear to lose any more fertilizer than is the case on the irrigated ones. A number of experiments trying this are now being laid out along the Hilo coast.

**TIME OF APPLICATION OF NITROGEN**  
**PIONEER MILL CO. EXP. 56, 1927 CROP**  
**Field C-4. First Ratoons.**



In addition to these small experimental areas we hope to have a number of large fields treated in the same manner in order that we may study the effect on the juices in a large way.

It was recently the writer's privilege to visit a large field of plant cane on the Hilo coast. This was as fine a field of cane as I have seen, and the manager is safe in talking about 100 tons per acre. But the most interesting thing about this field is that it received all its fertilizer within six months of planting.

### Detailed yields by plot:

**FIELD C-4—PIONEER MILL COMPANY—EXPERIMENT NO. 56—**  
**“TIME OF APPLICATION OF N.”**

## The Cause of Sectional Chlorosis of Sugar Cane

BY FREDERICK C. NEWCOMBE AND H. ATHERTON LEE

The name sectional chlorosis was first used by W. P. Naquin, manager of the Honokaa Sugar Company, to designate a white horizontal marking or banding of sugar cane leaves; the white marking usually extended completely across the

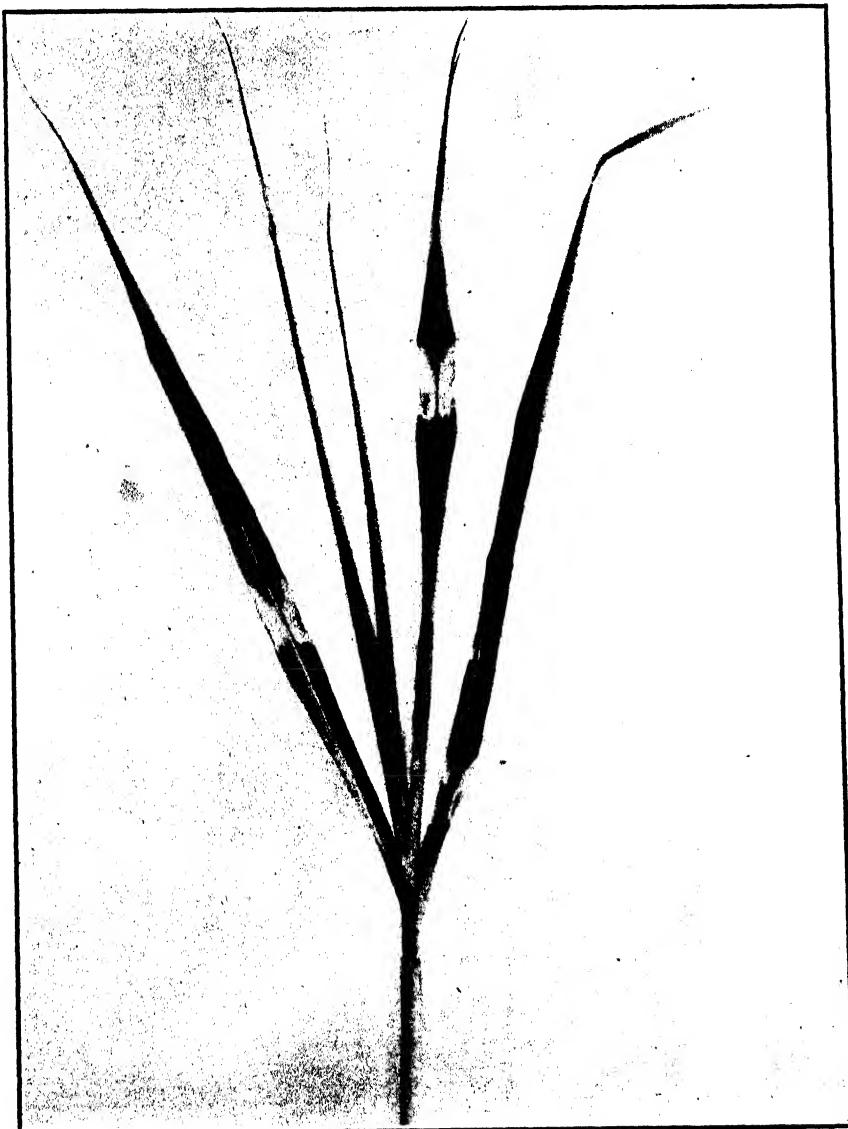


Fig. 1. A cane top of the variety H 109 from Waianae, showing the whitened sections of the leaves known as sectional chlorosis. The occurrence of these chlorotic sections near the base of the oldest leaf, and higher up on each succeeding younger leaf, is explained by the synchronous occurrence of the injury to all leaves when they were closely wrapped together in the central cylinder or spindle.

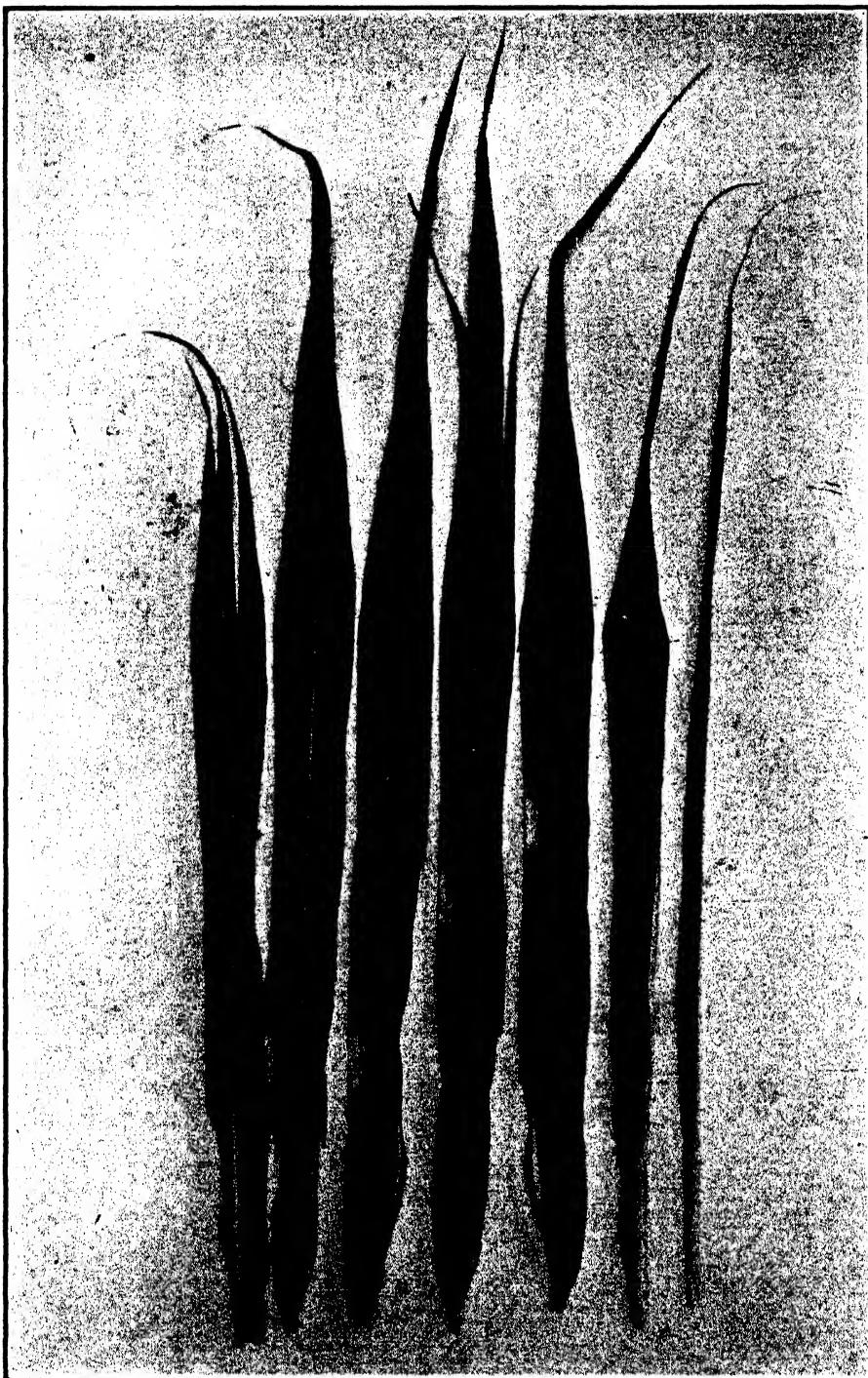


Fig. 2. Leaves of a cane stalk arranged in order of their age; the oldest leaves at the left and the youngest at the right. As in the case of the illustration in Fig. 1, the sectional chlorosis near the base of the oldest leaf, and occurring higher up on each successive younger leaf is explained by the synchronous occurrence of injury while the affected areas were contiguous to each other in the spindle or central cylinder. Injury from low temperatures in the central cylinder has reproduced this type of chlorosis experimentally.



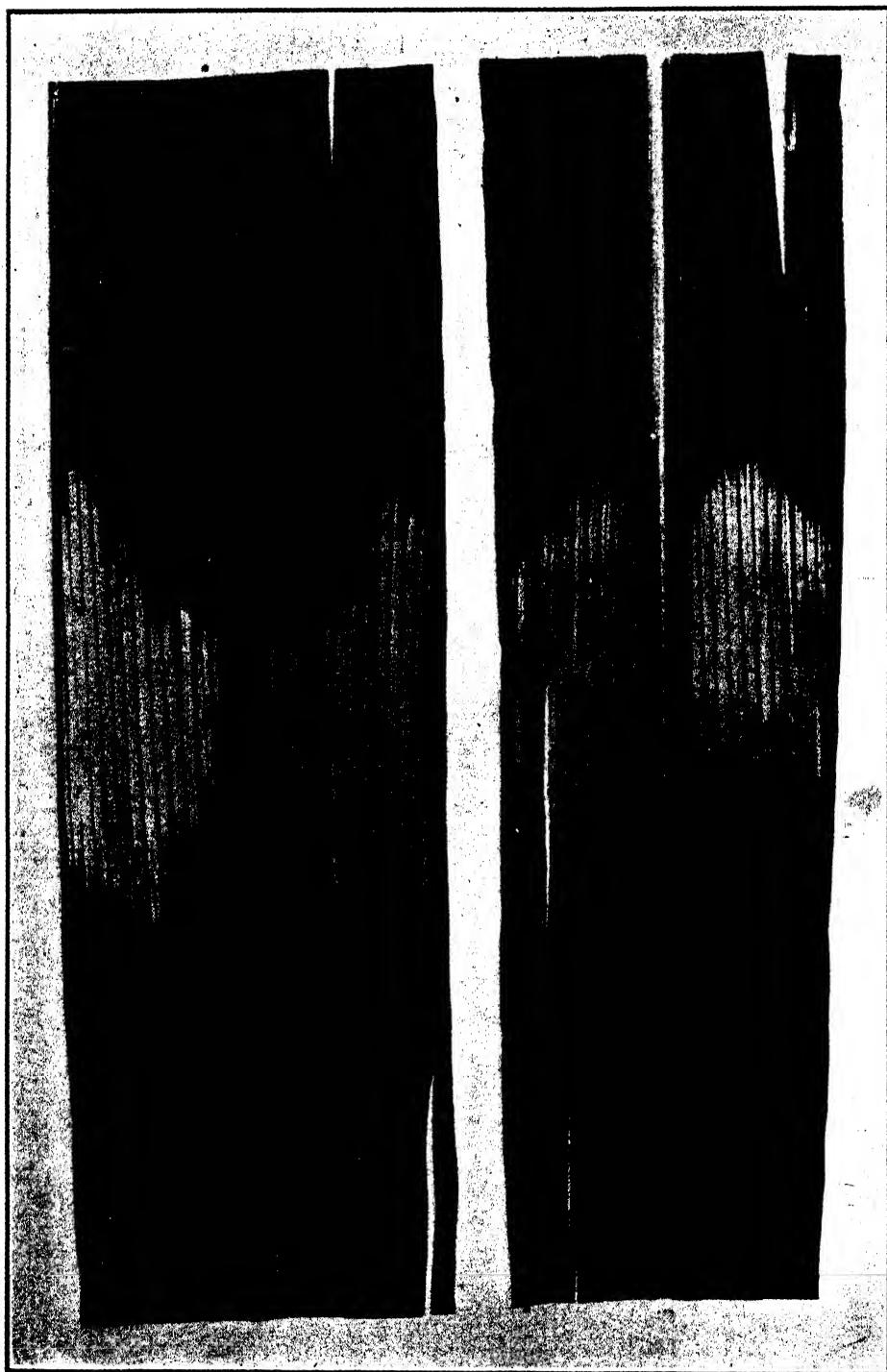


Plate 1. A colored illustration showing the nature of sectional chlorosis on leaves of H 109. This type of chlorosis can be reproduced experimentally by low temperatures at the central cylinder or spindle of the cane top.

leaf from one edge to another and varied in width from one-half inch in some cases to 3 or 4 inches in others. This marking of the leaves was observed at Honokaa and Mountain View on the island of Hawaii, and later, in March, 1924, in whole fields of H 109 at Waianae Company and on the Waianae side of Ewa Plantation Company. The appearance of this sectional chlorosis is shown in Plate 1 and in the illustrations in Figs. 1 and 2.

The injury evidently takes place in the central cylinder of the cane top as evidenced by the positions of the white markings on the leaves, since the youngest leaves show the markings near their tips, the next older leaves show the markings further down the leaf blade, and the oldest leaves show the markings near the bases of the blades. If the injury occurred to all these leaves at one time, then the leaves must have had the positions of the markings contiguous to one another, which must therefore have occurred in the spindle or central cylinder.

No serious injury resulted to the cane at the time and the affected leaves matured and were replaced by unaffected normal leaves. The cause of this uniform marking on all plants in a field, however, occasioned considerable interest. In the cases of sectional chlorosis at Waianae and Ewa, there were in some fields two blanched areas to a leaf and the time of origin of these areas seemed to coincide closely with the occurrence of two kona storms. Theories were advanced that the marking resulted from salt spray blown from the sea, during these storms, which washed into the central cylinders of the cane. Also the theory was advanced that the chlorosis resulted from water at low temperatures lying in the central cylinders of the cane for long periods.

An experiment was tried here in Hawaii later in the year 1924 in which ice-cooled water was allowed to run from a bucket into the central cylinder of the cane for a period of three days, but no chlorosis resulted.

Faris\*, an investigator in Cuba, however, formed an inverted cone of paper around the spindle of the cane, and placed cracked ice in the cone for three successive nights; eight to ten days later the sectional chlorosis appeared on the young cane leaves coming from the central cylinder. He found the varieties H 109 and D 1135 especially susceptible, while from field observations he found Badila, P. O. J. Nos. 36, 213, 234, 979, 2714, Kassoer Uba and Cristalina to be resistant. His observations led to the opinion that cane which was in an actively growing, succulent condition was more susceptible than slow-growing cane with hardened leaves.

In order to confirm the results of Faris, his methods were duplicated here in Hawaii. On the nights of January 15th, 16th and 17th, 1927, starting at 5:00 p. m., cracked ice was placed in inverted cones of Manila paper tied around the sugar cane stem just below the spindles of the cane. Ten stalks of H 109 were treated with ice in this way, while untreated stalks in the same stools were left as controls. The ice was maintained throughout each night, but no effort was made to keep the cones filled with ice throughout the day. Usually, however, small amounts of ice remained in the cones until 10:00 or 11:00 o'clock of the

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\* Faris, James A. Cold chlorosis of sugar cane. *Phytopathology*, Vol. 16, No. 11, Nov., 1926, p. 885.

following morning, while on the last day, the weather being cloudy, the ice did not melt completely in some cones until late in the afternoon.

The water from the melted ice was allowed to run out through the lower tips of the cones and usually ran off down the stems; however, a considerable part of the time, standing water of low temperature must have rested in the central cylinders of the cane also from the gradual melting of the ice.

On January 24th, chlorotic areas were evident on the newest emerged leaves of the treated canes, which were typical of sectional chlorosis as it occurs naturally. Untreated canes in the same stools with the treated canes were unaffected and normal.

The experiment indicated clearly that sectional chlorosis could be caused by low temperatures at the spindle of the cane. One would not be warranted in concluding, however, that low temperatures are the cause of all cases of sectional chlorosis, but the foregoing experiments will explain many of the occurrences of this peculiar marking.

Although we used ice in these experiments, air diffusion and the insulation of cane leaves would cause the temperature in the growing point to be considerably above ice temperatures of 32° F., possibly the temperatures inside the central cylinder would be 40 or 42° F.

The coldest temperatures at Waianae and Ewa for the winter of 1923-1924 occurred on January 16th, when 50° F. was recorded at Ewa, and on January 18th, when 55° F. was recorded at Waianae. Mr. Voorhees, in charge of the station of the U. S. Weather Bureau in Honolulu, stated that these temperatures were recorded in weather instrument shelters and on a still night would be several degrees higher than the air in an open cane field.

A report of a publication by the United States Weather Bureau summarized by J. W. Smith\* shows that leaf temperatures at night may be 9 to 10° F. below atmospheric temperatures. This being the case, atmospheric temperatures of 50 to 55° F. in instrument shelters would result in leaf temperatures well within the range in which we reproduced this sectional chlorosis. The condition of the cane undoubtedly has also an influence on the occurrence of this sectional chlorosis.

Sectional chlorosis has never caused serious loss, but with the present understanding of its cause there is still less reason to feel concern where it occurs.

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\**Agricultural Meteorology*. The MacMillan Co., 1920, p. 75.

## Variety Test

### GROVE FARM EXPERIMENT 11\*, 1923, 1925, 1927 CROPS

This experiment compares the standard variety of cane, Yellow Caledonia, with a number of the H 400 seedlings.

This test was in Field 11B, irrigated and of medium elevation. Three crops have been harvested, plant, first ratoon and second ratoon.

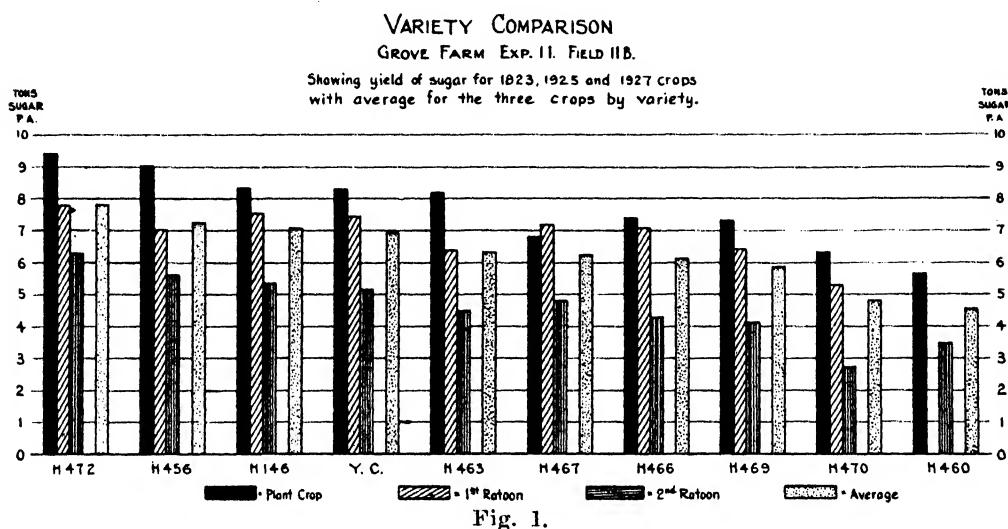


Fig. 1.

The results are given in the following table:

### GROVE FARM COMPANY, LTD., EXPERIMENT 11, 1927 CROP

January 8, 1927  
Variety Experiment—Field 11B  
Harvesting results of plant, first and second ratoons  
Varieties arranged in their order of yield

Variety	Crop	Brix	Pol.	Pur.	Q. R.	T. C. P. A.	T. S. P. A.	Average 3 crops	
								T. C. P. A.	T. S. P. A.
H 472	Plant ..	16.88	14.74	87.3	9.02	85.33	9.42	67.02	
	1st Rat.	18.20	15.57	85.5	8.58	60.75	7.80		
	2nd Rat.	17.70	15.48	87.5	8.70	54.98	6.31		
H 456	Plant ..	18.00	15.79	87.7	8.39	73.98	9.06	59.64	
	1st Rat.	17.27	15.38	89.1	8.54	60.36	7.07		
	2nd Rat.	18.10	16.51	91.2	7.90	44.58	5.64		
H 146	Plant ..	17.82	15.85	88.9	8.27	69.27	8.38	57.09	
	1st Rat.	18.55	16.80	90.6	7.77	58.96	7.59		
	2nd Rat.	18.40	16.53	89.9	8.00	43.05	5.38		

\* Experiment planned and laid out by John H. Midkiff. Experiment harvested, plant and first ratoon, by O. C. Markwell; second ratoon by Raymond Conant.

Variety	Crop	Brix	Pol.	Pur.	Q. R.	T. C. P. A.	T. S. P. A.	Average 3 crops		
								T. C. P. A.	T. S. P. A.	
Y. C.	Plant ..	17.67	15.18	86.2	8.78	73.10	8.32			
	1st Rat.	18.67	16.75	89.7	8.71	58.54	7.49	59.68	6.98	
	2nd Rat.	17.70	15.04	85.0	9.20	47.40	5.15			
H 463	Plant ..	17.35	15.42	88.9	8.54	70.14	8.21			
	1st Rat.	17.10	15.90	88.2	8.75	56.12	6.41	54.78	6.38	
	2nd Rat.	18.10	15.88	87.8	8.40	38.10	4.52			
H 467	Plant ..	16.30	13.74	84.3	9.84	67.12	6.82			
	1st Rat.	18.30	16.45	89.9	7.97	57.28	7.19	55.96	6.28	
	2nd Rat.	17.80	15.16	85.2	9.00	43.48	4.83			
H 466	Plant ..	16.89	14.76	87.4	8.96	66.46	7.42			
	1st Rat.	18.40	16.31	88.6	8.09	57.49	7.11	55.08	6.17	
	2nd Rat.	16.80	14.32	85.2	9.60	41.31	4.30			
H 469	Plant ..	16.70	14.26	85.4	9.38	67.27	7.17			
	1st Rat.	17.70	15.40	87.0	8.63	55.53	6.43	54.56	5.92	
	2nd Rat.	17.20	14.32	83.2	9.80	40.88	4.17			
H 470	Plant ..	17.67	15.32	86.7	8.71	55.60	6.37			
	1st Rat.	17.80	15.59	87.6	8.49	45.70	5.31	43.95	4.81	
	2nd Rat.	16.10	12.93	80.3	11.10	30.56	2.75			
H 460	Plant ..	15.95	13.48	84.5	10.00	56.55	5.66			
	1st Rat.	No Sample				50.17	...	48.18	4.58	
	2nd Rat.	16.20	13.17	81.3	10.80	37.82	3.50			

An average of the three crops shows that H 472, H 456 and H 146 have given better yields than the Yellow Caledonia checks. As these canes are much more resistant to eye spot than H 109, it should be worth while to plant them in bad eye spot areas.

These canes probably require a little more care at the start of a crop as they are inclined to be weak ratooners.

H 456 has averaged better juices than either H 472 or Yellow Caledonia. This cane is being spread on three of the plantations on Kauai. There are almost 300 acres of H 456 planted for the 1928 crop on Kauai. Yellow Caledonia and H 146 had less rotten cane in the plant crop than any of the others. H 472 had some damaged cane in the plant crop.

The two poorest canes, H 470 and H 460, were badly rotted in all three crops.

TABLE SHOWING TOTAL CANE AND SUGAR FOR THE THREE CROPS BY VARIETY ARRANGED IN ORDER OF THEIR SUGAR YIELD

Variety	Total cane per acre for 3 crops	Total sugar per acre for 3 crops	Gain or loss of varieties over Yellow Caledonia	
			cane	sugar
H 472 .....	201.06	23.53	+22.02	+2.57
H 456 .....	178.92	21.77	— .12	+ .81
H 146 .....	171.28	21.35	— 7.76	+ .39
Y. C. .....	179.04	20.96	0.00	0.00
H 463 .....	164.36	19.14	—14.68	— .82
H 467 .....	167.88	18.84	—11.16	—2.12
H 466 .....	165.26	18.83	—13.78	—2.13
H 469 .....	163.68	17.77	—15.36	—3.19
H 470 .....	131.86	14.43	—47.18	—6.53
H 460 .....	144.54	9.16	—34.50	—11.80*

\*Omitted from graph—sugar yield on 2 crops only.

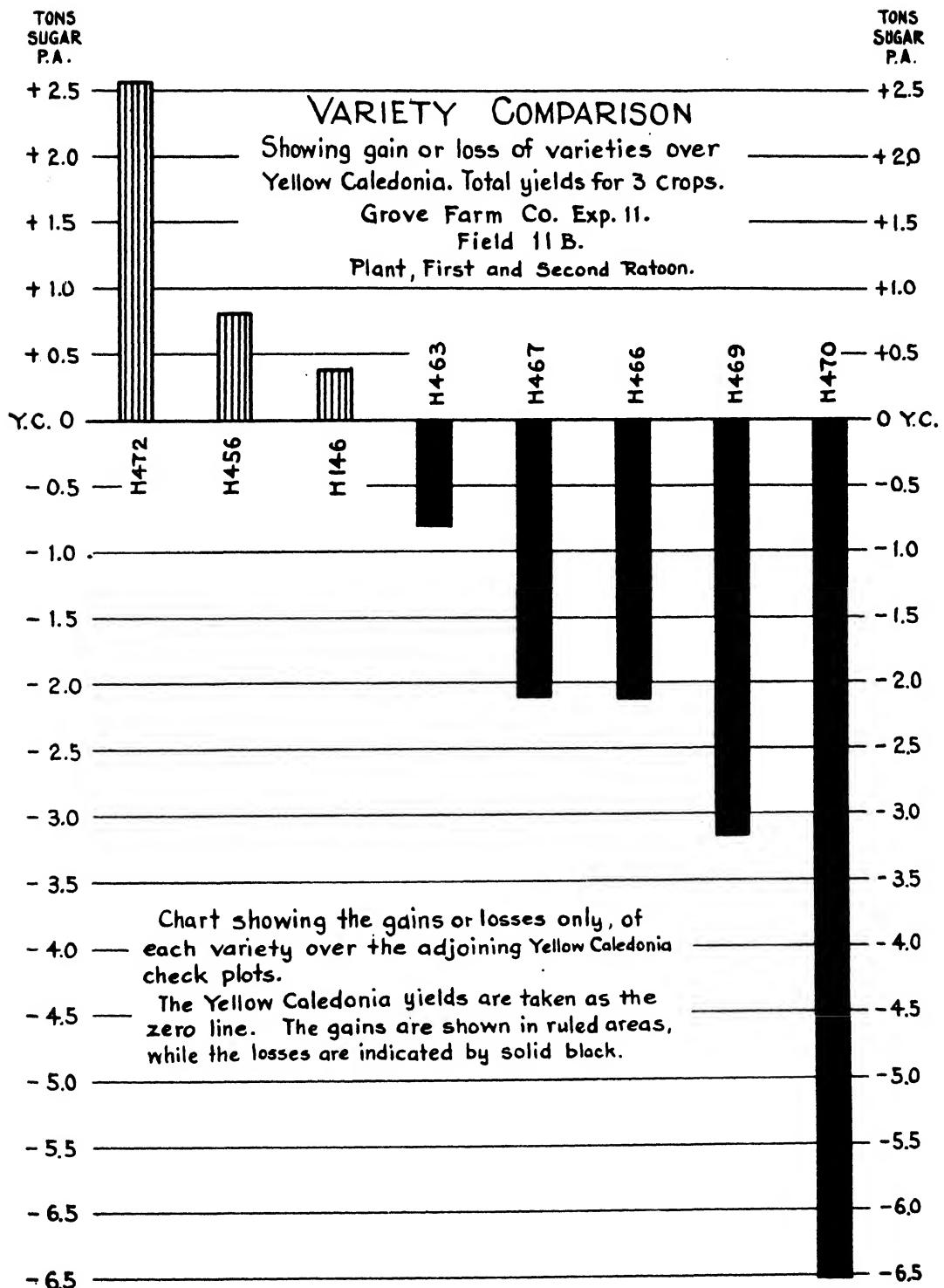


Fig. 2.

## DETAILS OF EXPERIMENT

- Object:** To compare H 146 and a number of H 400 seedlings with Yellow Caledonia at Grove Farm.
- Location:** Field 11B.
- Crop:** Plant, first ratoons, second ratoons.
- Layout:** Number of plots, 104. Size of plots, 1/10 of an acre, 50' x 87'; consisting of 18 straight lines each 50' x 4.84'. Twenty of these plots are 1/20 of an acre, each consisting of 9 straight lines.
- Fertilization:** Uniform to all plots.
- Progress:** July 7-14, 1921—Seed cut and planted.  
 March, 1923—Plant crop harvested.  
 June, 1923—Cane cut back.  
 February 18-25, 1925—First ratoon crop harvested.  
 January 8-13, 1927—Second ratoon crop harvested.

R. E. D.

## Amount of Nitrogen at Pioneer Mill Company

## PIONEER MILL CO. EXPERIMENT 23\*, 1925 AND 1927 CROPS

This experiment was planned to determine the most profitable amount of nitrogen to use at Pioneer. It has been carried on for two crops, one plant and one ratoon. It is laid out in Field G2 at an elevation of 450 feet. This field is irrigated and planted to H 109 cane. In the plant crop phosphoric acid was applied to all plots at the rate of 100 pounds per acre, and potash at the rate of 50 pounds per acre. The phosphoric acid was increased to 150 pounds, and the potash to 100 pounds per acre, uniformly for all plots, for the first ratoon crop.

In this experiment the comparison is made between 137, 180, 230 and 280 pounds of nitrogen for the plant crop, and between 140, 190, 240 and 290 pounds of nitrogen per acre in the case of the first ratoon crop. The fertilizer was applied in September, 1923, January, 1924, and February, 1924, for the plant (1925) crop. The ratoons were fertilized in July, 1925, and in February, 1926. The treatments and the results obtained for the two crops are summarized in the following tables:

\* Experiment planned by J. A. Verret. Experiment laid out by F. W. Broadbent. Experiment harvested, plant crop by F. W. Broadbent, first ratoon by D. M. L. Forbes.

## AMOUNT OF NITROGEN—SUMMARY OF RESULTS

Plant Crop—1925

No.		Treatment	T. C. P. A.	Yields	
Plots	of Plots			Q. R.	T. S. P. A.
D	7	132 pounds Nitrogen.....	64.0	6.30	10.15
E	7	180 pounds Nitrogen.....	66.8	6.32	10.58
F	7	230 pounds Nitrogen.....	73.3	6.50	11.28
G	7	280 pounds Nitrogen.....	74.1	6.60	11.23

**NITROGEN-AMOUNT TO APPLY**  
**Pioneer Mill Co. Exp. 23, 1925 crop**  
**Plant Cane**

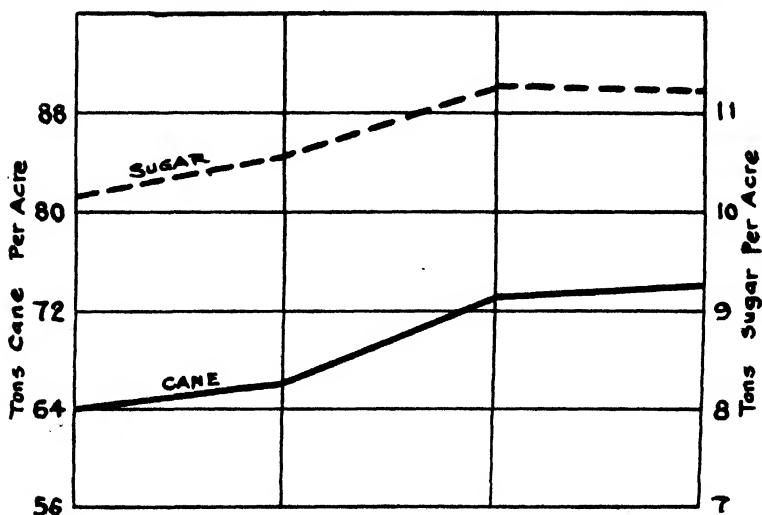
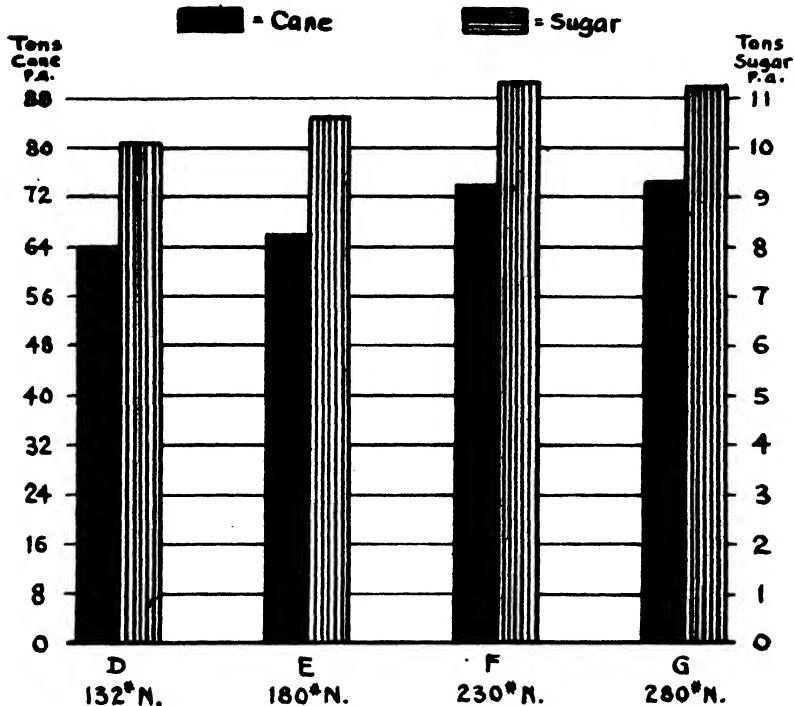


Fig. 1.

**NITROGEN - AMOUNT TO APPLY**  
 Pioneer Mill Co. Exp. 23, 1925 Crop  
 Plant Crop  
 Curves Showing Cane Yields Per Acre By Plots.

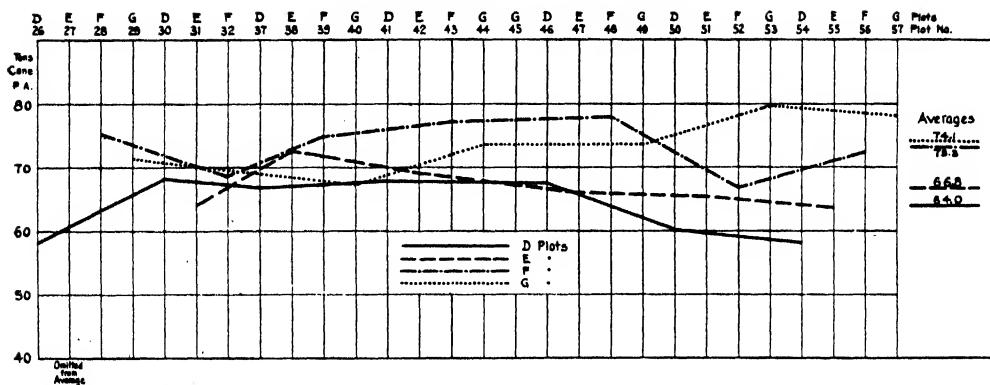


Fig. 2.

These results of the plant crop would indicate that 230 pounds of nitrogen per acre was the most profitable amount of this element to use under the conditions of this test.

The results of the first ratoon crop are summarized as follows:

**AMOUNT OF NITROGEN—SUMMARY OF RESULTS**

First Ratoon Crop—1927

Plots	No. of Plots	Treatment	Yields		
			T. C. P. A.	Q. R.	T. S. P. A.
D	7	140 pounds Nitrogen.....	57.5	7.23	7.94
E	7	190 pounds Nitrogen.....	67.6	7.52	8.99
F	7	240 pounds Nitrogen.....	74.2	7.96	9.29
G	7	290 pounds Nitrogen.....	78.2	8.13	9.62

The results of the first ratoon crop show substantial gains up to 290 pounds. The last 50 pounds of nitrogen produced an increased yield of one-third of a ton of sugar per acre.

**DETAILS OF EXPERIMENT**

**Object:** To determine the most profitable amount of nitrogen to use.

**Crop:** H 109. Planted July, 1923.

**Location:** Pioneer Mill Company, Field G2. Elevation 450 feet.

**Layout:** 28 plots, of variable size, 7 repetitions of each treatment. Experimental area, 2.221 acres net.

**NITROGEN-AMOUNT TO APPLY**  
**Pioneer Mill Co. Exp. 23, 1927 crop**  
**First Ratoons**

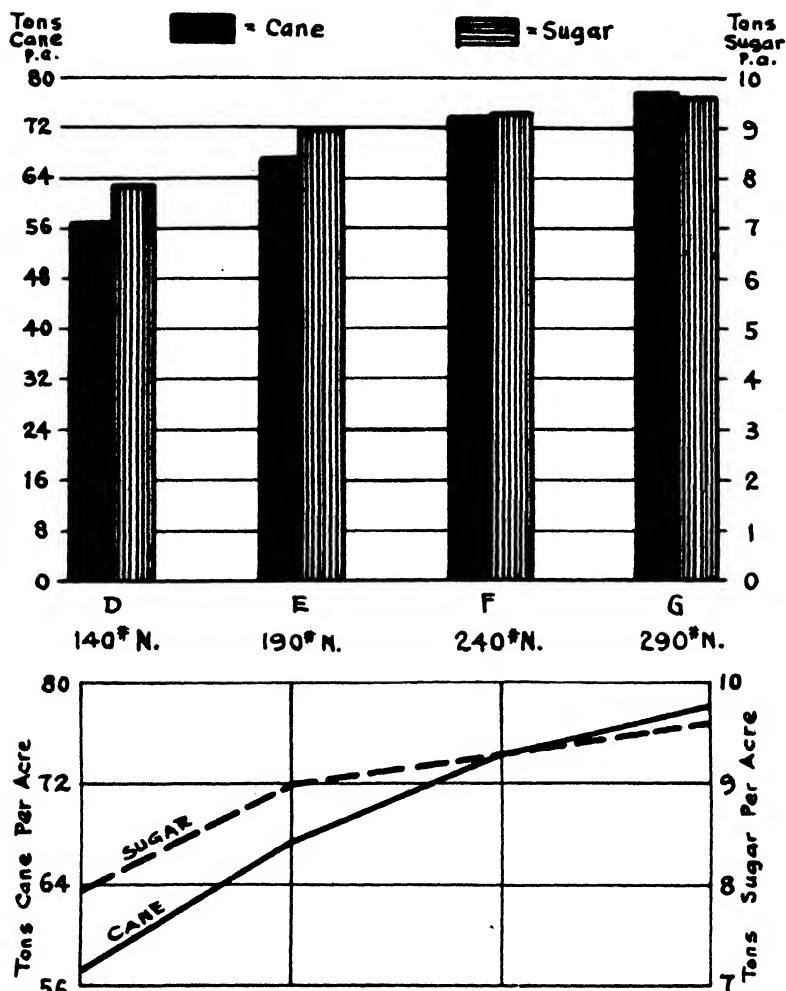


Fig. 3.

**FERTILIZATION OF PLANT CROP**

Sept., 1923

Plots	No. of Plots	Amm.	Acid	Pot.	Jan., 1924	Feb., 1924	Totals		
		Sul.	Phos.	Sul.	N. S.	N. S.	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
D	7	220	476	100	563	...	132	100	50
E	7	342	476	100	563	147	180	100	50
F	7	463	476	100	563	308	230	100	50
G	7	585	476	100	563	470	280	100	50

Acid Phosphate = 21% P<sub>2</sub>O<sub>5</sub>.

Ammonium Sulphate = 20.5% N.

Nitrate of Soda = 15.5% N.

Sulphate of Potash = 50% K<sub>2</sub>O.

## NITROGEN - AMOUNT TO APPLY

Pioneer Mill Co. Exp. 23, 1927 Crop

First Ratoons

Curves Showing Cane Yields Per Acre By Plots.

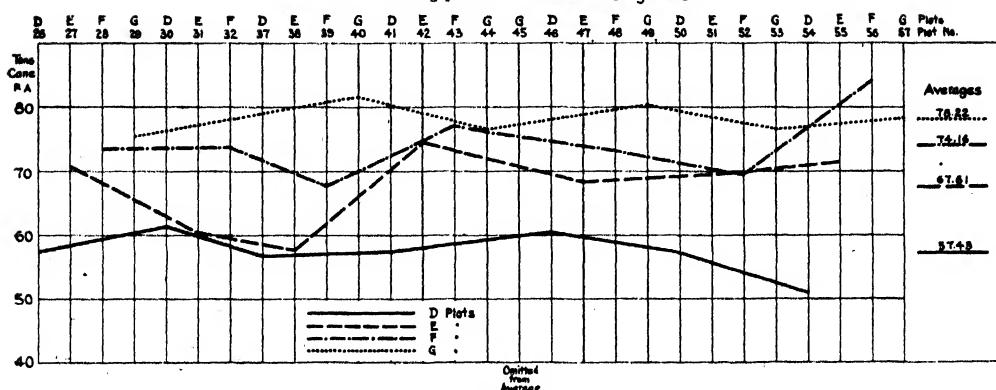


Fig. 4.

## FERTILIZATION OF FIRST RATOON CROP—LBS. PER ACRE

July, 1925

Plots	No. of Plots	Amm.	Acid	Pot.	Feb., 1926	Totals					
						Sul.	Phos.	N. S.	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O
D	7	342	750	204	452	140	150	100			
E	7	463	750	204	613	190	150	100			
F	7	585	750	204	774	240	150	100			
G	7	707	750	204	936	290	150	100			

Ammonium Sulphate = 20.5% N.

Acid Phosphate = 20% P<sub>2</sub>O<sub>5</sub>.Potash Sulphate = 49% K<sub>2</sub>O.

Nitrate of Soda = 15.5% N.

**Progress:** September 26, 1923—Experiment laid out and first fertilizer applied.

January 18-19, 1924—Nitrate of soda applied by plantation.

February 14, 1924—Nitrate of soda applied to "E," "F" and "G" plots.

May 2-5, 1925—Plant crop harvested.

July, 1925—First season fertilizer applied to ratoons.

February 9, 1926—Second season nitrate of soda applied to experiment.

January 6-8, 1927—First ratoon crop harvested.

R. E. D.

## Relationship Between Phosphoric Acid, Lime Used and Amount of Press Cake

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By J. H. PRATT

The tabulation below gives weekly figures from laboratory records showing relationship between the  $P_2O_5$  of crusher juice, amount of lime used and the percentage of press cake at the Pioneer Mill Company's factory for the crop of 1926.

There are several influencing factors which should be born in mind.

1. Several weeks, we boiled off the juice in the settling tanks, so there would be about 4 tons more mud these weeks than usual. I have no record of which weeks we did this, but think that the mud per cent cane should be corrected as follows: December 5 add .10 per cent, December 12 deduct .05 per cent, December 19 deduct .04 per cent, January 9 add .04 per cent. I think the rest of the weeks are all right.
2. We ground a considerable quantity of sour cane during the latter part of December, which gave these weeks an undue amount of mud.
3. Our lime figures are those of the lime slaked and not those actually used. I do not think that this would make any serious difference except to the first week and last week of the crop.
4. The actual  $P_2O_5$  in the mixed and crusher juice is an arithmetical average based on the number of samples and not on the tons of cane. This difference is probably not very serious either.
5. In getting the calculated  $P_2O_5$  in crusher juice, I multiplied the tons of cane from each field by the average  $P_2O_5$  for that field. This is not strictly accurate as most of our fields are on a steep slope and the  $P_2O_5$  is higher at the bottom of the field than it is at the top. Some of the weeks, when we were getting perhaps 40 per cent of our cane from one field, may be slightly off for this reason.
6. The pH of the mixed juice is the cold and not the hot juice.
7. The pH of the clarified juice does not include press juice or the juice from tanks held over shutdowns of more than 3 hours.
8. During part of the crop some of the lime reported was used in the mud while at other times we cut this out. This might make some difference in the figures.
9. As about half the crop was ground single shift, I have included the approximate hours ground per day, although I don't think that the extra lime added to the juice held over night would make much difference to the averages.

TABLE SHOWING MUD PER CENT CANE, POUNDS LIME PER TON CANE, pH OF JUICES, ACTUAL  $P_2O_5$  IN MIXED AND CRUSHER JUICE AND CALCULATED  $P_2O_5$  IN CRUSHER JUICE

Week	Per cent mud	Lbs. lime	Actual $P_2O_5$		Cale. crush	pH of Juice			Hours per day
			mixed	crush		mixed	clarified	syrup	
12-5	4.22	2.45	...	...	.038	8.94	7.96	7.31	14
12-12	4.77	1.46	...	...	.039	8.71	7.66	7.22	21
12-19	4.93	1.62	...	...	.022	8.75	7.62	7.37	22½
12-26	5.17	2.34	...	...	.020½	9.01	7.66	7.44	17½
1 -2	4.33	2.13	...	...	.022¼	9.07	7.70	7.43	21
1 -9	3.58	1.46	...	...	.022	8.99	7.82	7.49	20
1 -16	4.13	1.47	...	...	.020½	8.86	7.71	7.44	22½
1 -23	4.17	1.37	.024	.025½	.023	8.86	7.65	7.31	19½
1 -30	3.52	1.35	.021	.022¼	.020¾	8.81	7.67	7.48	23
2 -6	3.30	1.35	.019	.019	.019½	8.89	7.67	7.49	19
2 -13	3.87	1.36	.018	.018	.018	8.80	7.68	7.56	21
2 -20	4.02	1.45	.017	.018¾	.018¼	8.73	7.69	7.52	21
2 -27	3.18	1.40	.016½	.017	.017½	8.75	7.71	7.61	21
3 -6	3.56	1.36	.018½	.019	.018¼	8.80	7.67	7.51	19
3 -13	4.23	1.52	.016	.017	.017½	8.65	7.64	7.44	17
3 -20	4.09	1.57	.015	.016	.015½	8.70	7.68	7.40	16
3 -27	3.49	1.50	.016	.017	.016¼	8.80	7.74	7.40	12
4 -3	3.41	1.64	.014	.015	.014	8.73	7.75	7.41	11
4 -10	3.09	1.41	.014	.015¾	.016	8.62	7.68	7.31	12
4 -17	3.11	1.53	.014	.015¼	.016	8.88	7.86	7.41	10
4 -24	3.61	1.49	.014½	.014¾	.015	8.83	7.86	7.46	10½
5 -1	3.64	1.48	.016	.017½	.017½	8.75	7.90	7.43	10½
5 -8	3.16	1.47	.019	.020	.016½	8.83	7.81	7.45	10½
5 -15	3.08	1.43	.018	.018	.017	8.58	7.73	7.43	11
5 -22	3.29	1.62	.022	.022½	.018	8.62	7.74	7.42	11½
5 -29	3.02	1.43	.018	.017½	.020½	8.77	7.86	7.37	11½
6 -5	3.20	1.70	.026	.026½	.021	8.72	7.72	7.30	11
6 -12	3.15	1.63	.021	.021½	.019	8.80	7.77	7.40	11
6 -19	4.73	2.00	.029	.030½	.022½	8.69	7.69	7.51	8
6 -26	3.63	2.05	.026½	.027	.025	8.73	7.67	7.54	10½
7 -2	4.65	2.30	.043	.049½	.050½	8.62	7.52	7.29	9½
7 -10	4.85	1.82	.053½	.064	.064½	8.79	7.35	7.05	8

## Irrigation Investigations at Waimanalo

BY T. K. BEVERIDGE  
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Two reports on the cooperative irrigation investigations at Waimanalo have appeared in the *Record* of April, 1924, and October, 1925. The present report deals with the continuation of these studies along several new lines which have been developed since the last report. The work has been continued as a joint endeavor of the Experiment Station, H. S. P. A., and Waimanalo Sugar Company.

### SOURCES, AMOUNTS OF IRRIGATION WATER, AND DITCHES

Waimanalo Sugar Company is entirely dependent on the rainfall for its source of irrigation water and has no artesian supply whatsoever. Under the best of conditions the maximum economical supply available for any one day is a little over ten million gallons; the average daily delivery for the year, however, is only slightly over eight million gallons. This supply is delivered to the plantation from three sources, as follows:

1. The Maunawili-Waimanalo Ditch;
2. The Kailua Pump Ditch;
3. The Lagoon Pump Ditch.

The Maunawili-Waimanalo ditch, receiving its water from numerous small springs and streams along its course, runs along the top of the plantation, and its delivery averages about two million gallons daily.

The Kailua pump ditch is fed from a large swamp at Kailua. This swamp is nothing more than a storage reservoir for the surface run-off from the Kailua Valley. The water, lifted 180 feet by pumps to a series of tunnels, enters the premises about a hundred feet below the Maunawili-Waimanalo ditch and runs through the middle portion of the plantation. This source supplies close to four million gallons of water a day or approximately one-half of the irrigation water.

The lagoon pump ditch runs through the lower levels of the plantation about one hundred feet below the Kailua ditch. The water is lifted 80 feet from a lagoon on the plantation at the rate of a little over two million gallons per day.

All of the ditches on the plantation, with the exception of some tunnels and a few short stretches of concrete ditch, are of the open-cut type running through the subsoil. These ditches average three feet in depth and three and one-half feet in width with a fall of about two-tenths per hundred feet.

#### WATER SUPPLY—SEASON 1926

	Maunawili-Waimanalo	Lagoon pump	Kailua pump
January . . . . .	3,719,790	478,640	.....
February . . . . .	12,524,680	29,688,430	43,999,200
March . . . . .	62,955,460	61,639,770	141,980,450
April . . . . .	66,087,190	71,863,570	117,006,210
May . . . . .	61,521,710	77,659,280	179,487,570
June . . . . .	63,348,260	31,020,960	45,906,740
July . . . . .	69,132,070	66,289,760	168,464,470
August . . . . .	61,099,940	78,343,910	191,057,040
September . . . . .	57,455,160	52,823,630	79,928,070
October . . . . .	68,253,570	39,301,020	50,257,090
November . . . . .	55,680,840	15,832,340	7,528,190

#### DITCH SEEPAGES

The ditch seepage losses at Waimanalo, although very high in some particular spots, are not abnormally large for this type of plantation ditch. From data that have been obtained during the year, it has been found that the total loss of

## Waimanalo Sugar Co.

Graph showing the amounts of irrigation water used per month over a period of three years, compared with the average monthly rainfall for the same period and showing how the rainfall varied from normal. Normal being a period of 36 years.

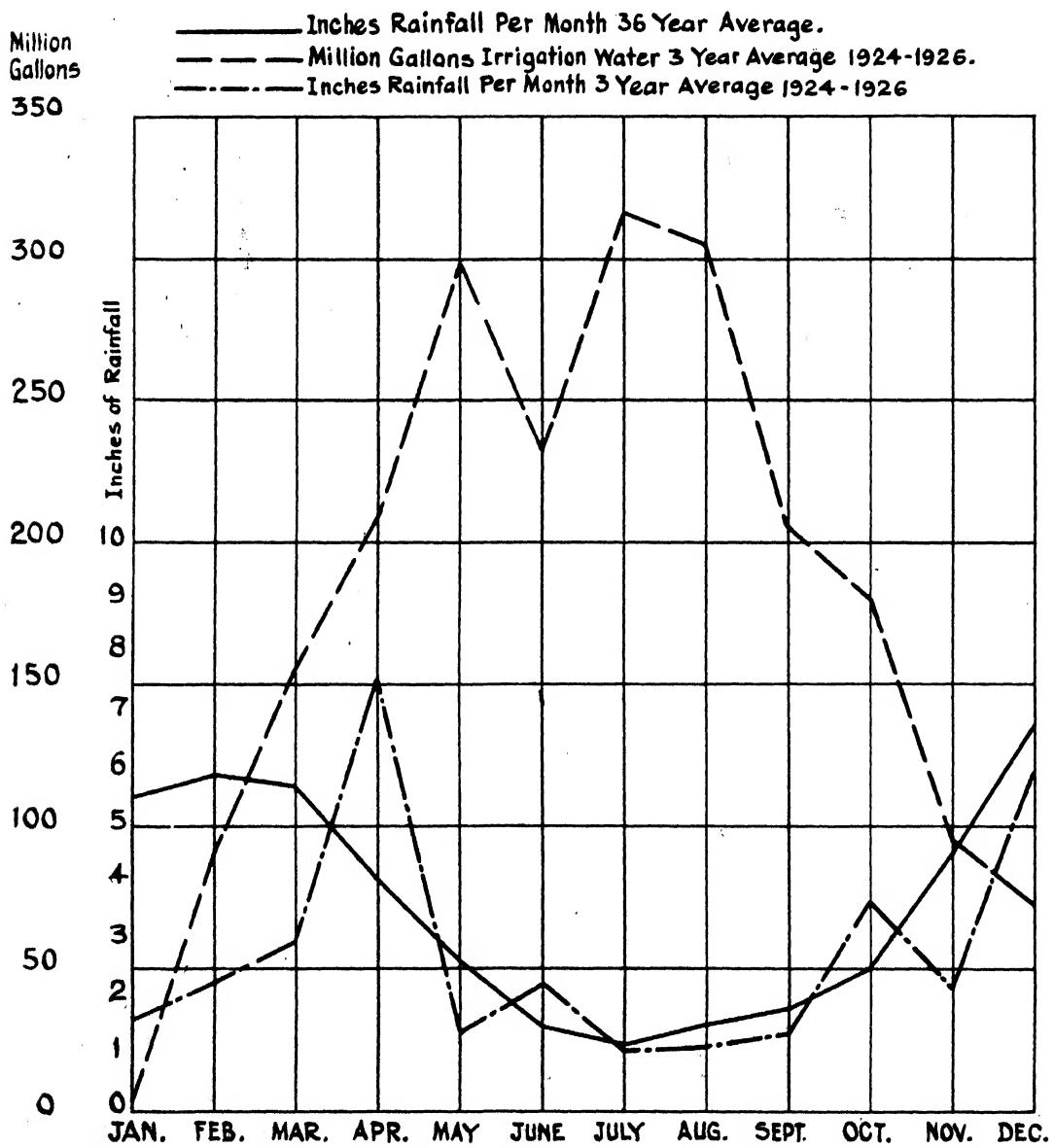


Fig. 1.

water over the whole plantation is only 20.60 per cent of the entire supply. This amounts approximately to 9.00 per cent per mile, showing that the ditches have been kept in a very good state of repair.

Seepage tests have been made on all of the ditches on the plantation so that whenever improvements are made on the ditches, the worst spots are gone over first and the amount of water that is being lost by ditch seepage is gradually being lessened.

Figures are presented below to show how it was possible to cut down losses in one ditch through seepage tests:

#### SEEPAGE LOSSES—MAUNAWILI DITCH

##### First Test

Location of measuring station	Distance between stations	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 16.....	.....	2,649,000	.....	....	....
Field 15.....	1,315 feet	2,340,000	139,000	5.23	21.00
Field 14.....	7,275 feet	2,113,000	356,000	14.42	6.67
Field 3.....	10,165 feet	1,299,000	1,170,000	47.39	17.13
Field 1.....	5,623 feet	1,125,000	1,344,000	54.43	6.38

#### WAIMANALO SUGAR CO. CROPPING & IRRIGATING

Tentative harvesting and irrigating schedule for five successive crops  
Showing the irrigation gradually tapers off after the month of June. June and July  
are the months when the greatest amount of irrigation water is used under normal conditions.

There is a gradual falling off of the economical water supply after these two months,  
September being the month when there is the least available water.

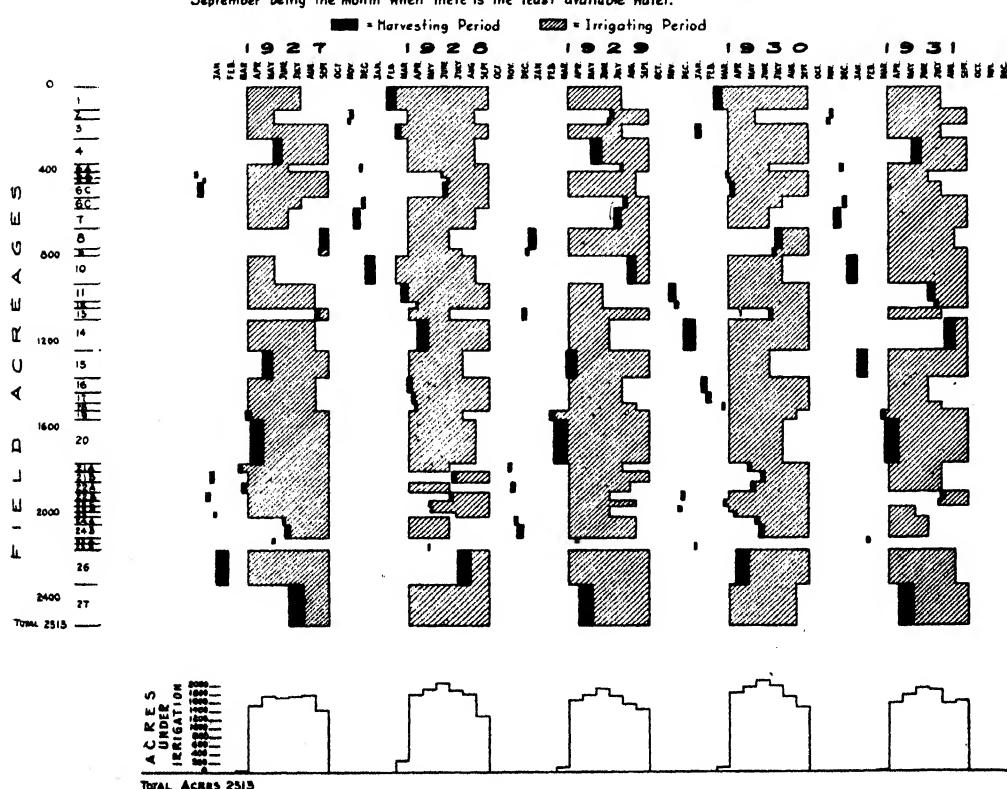


Fig. 2.

**Later Test After Repairing Ditches**

Field 16.....	.....	2,604,000	.....	....	....
Field 15.....	1,315 feet	2,469,000	135,000	5.17	20.80
Field 14.....	7,275 feet	2,146,000	458,000	17.58	9.01
Field 10.....	3,075 feet	1,984,000	620,000	23.79	10.69
Field 4.....	4,200 feet	1,981,000	723,000	27.76	4.84
Field 3.....	2,890 feet	1,745,000	859,000	32.95	9.56

During the year the question was brought up as to the loss of water in straight ditches that had cane growing along them. Two typical ditches were selected and weirs were installed at the tops and bottoms of these ditches. Water was run into the ditches twice, once when the cane was large, and once after the cane had been cut. On both occasions the weirs were identical, the same amount of water was run over the top weirs and the water was run over the bottom weirs the same length of time before readings were taken:

**STRAIGHT DITCH SEEPAGES WITH CANE**

Location of weirs	Distance between weirs	Total flow gallons per 24 hours	Seepage loss gallons per 24 hours	Per cent of total flow lost	Per cent loss per mile
Field 13 Top.....	.....	604,000	.....	....	....
Field 13 Bottom...	500 feet	490,000	114,000	18.87	200.10
Field 10 Top.....	.....	497,000	.....	....	....
Field 10 Bottom...	1,700 feet	292,000	205,000	41.25	128.10

**STRAIGHT DITCH SEEPAGES WITHOUT CANE**

Field 13 Bottom...	500 feet	585,000	19,000	3.15	33.40
Field 10 Bottom...	1,700 feet	460,000	37,000	7.45	23.10

**MEASURING STATIONS AND MEASURING DEVICES**

The measuring stations used are of two classes, the first being the main stations and the second the field stations. All of the main stations are of the standard rectangular contracted weir type, installed at the head of each ditch so that an accurate measurement is obtained of all of the water as it enters the plantation ditches. Water stage recorders, either of the Gurley or Freiz types have been installed with the weirs and are in constant use.

Field measuring stations are located at the end of each field in all main ditches. This method of installation is made possible by the fact that all of our ditches run at right angles to our fields. This eliminates the problem of putting in stations on each lateral or wing ditch and cuts down the number of stations to the minimum. All of the field measuring stations are of the submerged orifice type and when used correctly prove very satisfactory. They are, in addition, simple to operate. The Great Western Orifice Meter is used in conjunction with the submerged orifices to record the amount of water passing through any particular field measuring station. Five different sized orifices are used, depending on the

## Waimanalo Sugar Co.

Graphs showing the amounts of irrigation water  
and rainfall and the average monthly growth Curve.

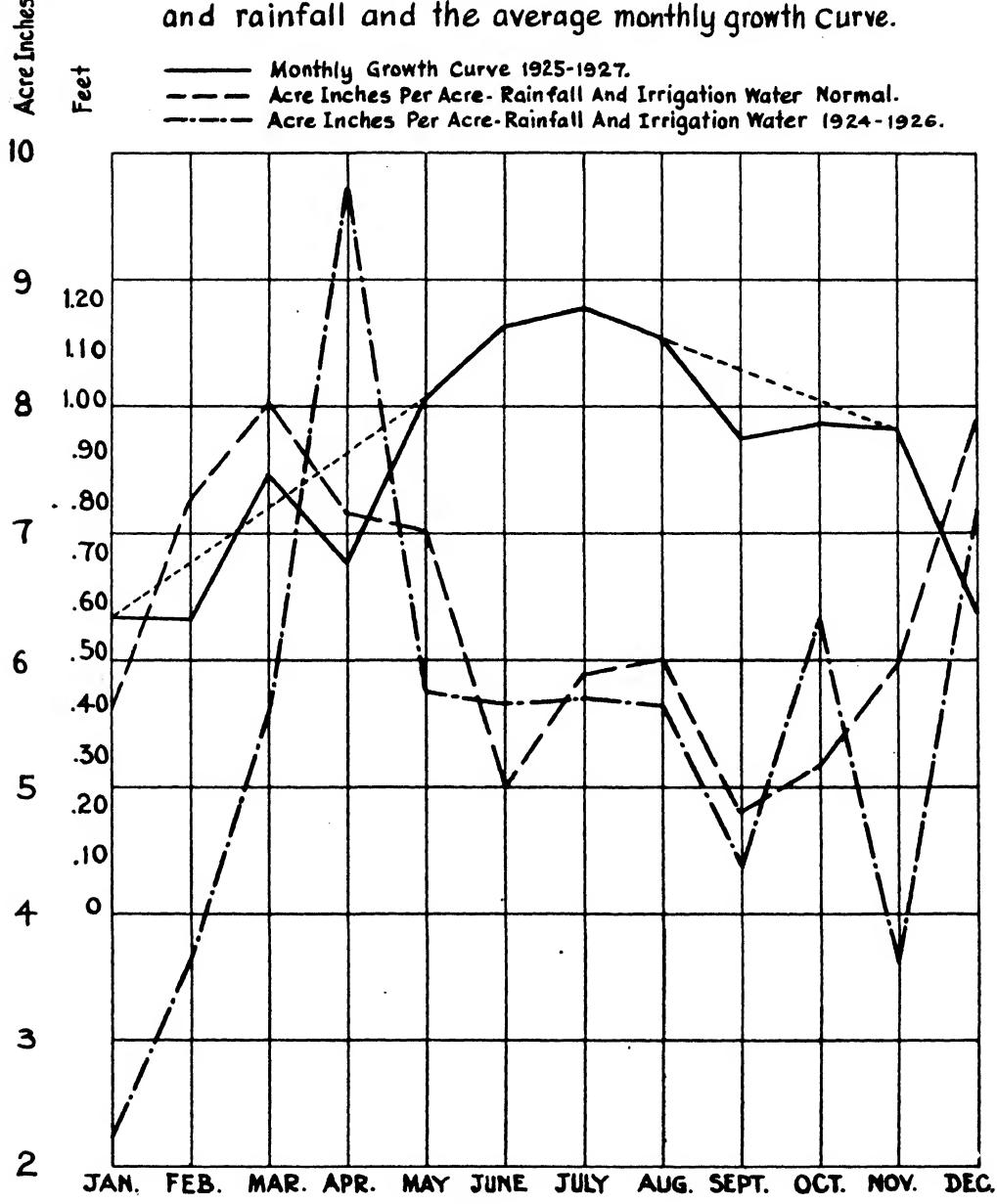


Fig. 3.

amount of water that passes through the measuring station and all can be interchanged easily and quickly.

One man has charge of setting the orifices and reading the meters and it is his duty to attend to all matters pertaining to the proper working of the various stations. In the morning he receives a list of the fields which are receiving water for the day. He immediately sets out to make the necessary adjustments for

the proper measuring of the water. If the irrigation is to be continued for several days the orifices remain in position all the time, except in cases where it is necessary to make changes. He always starts at the upper portion of the ditch and works down the field with the water.

The meters in use are read once a day at approximately the same hour, so that it is a very simple matter to obtain the amount of water passing through any given station. There are times, however, when, due to unforeseen circumstances, several changes have to be made during the day, but as a rule only one adjustment a day is necessary. The meter readings are turned in the following morning. The amount of water taken for any given field is the difference between the amount of water passing two stations, one at the end of the field, which is above this particular field and the other at the end of the field using the water. This system is used on all of the fields and so far has proven very satisfactory.

#### THE OBJECT OF WATER MEASUREMENTS

The objects of carrying on this careful measurement of water to all the fields are quite numerous, but chief among them is the duty of water, and this is the principal one here. How much sugar can be produced from a million gallons of irrigation water? This alone is a question which is being brought up more and more and the work here is being done with the idea of answering this question for the conditions to be met at Waimanalo.

Some questions the water measurements brought out very clearly are (1) Just how efficiently are the men using the water given them? (2) What are the irrigators doing in the fields? (3) Are they applying the water properly and yet covering the ground? After the first two irrigations this year it was possible to make the men in the fields cover about twice the ground that they were doing before this work was started. This increase in irrigating efficiency has brought the work up to a high degree of proficiency.

#### USEFUL INFORMATION RESULTING FROM THE MEASUREMENT OF IRRIGATION WATER

The information that can be obtained from this work is very important for the field man. It is possible through these measurements to tell with a considerable degree of accuracy (a) How much water is being applied per acre per round. (b) The amount of water each man is handling per round. (c) How much area is being covered and just how much water is required for each field. A very careful check can be kept of each individual field and after several irrigations a pretty fair average can be arrived at as to what a man can be expected to accomplish in each field. It is then just a question of careful supervision to keep the men up to whatever mark has been reached.

Measuring the water also helps to distribute irrigating cost to the fields on a more definite basis. The exact amount of water going to each field can be accounted for and the field charged accordingly. This method eliminates the

old way of distributing the amount of water in accordance with the irrigating man days.

One important result of this work of water measurements to fields is the knowledge of how much of the water that is delivered to the plantation is actually put on the fields. From the data obtained, month by month, the actual ditch seepage loss is determined. For plantations that have a very high water cost this phase of water measurements will be a very important and interesting one, especially in cases where the ditches are not lined. Data thus collected will give a very good idea as to whether the cost of lining these earth ditches will be warranted.

Month	Per cent loss of total flow	Approx. distance water traveled	Per cent loss per mile
February .....	19.75	2.20 miles	8.97
March .....	10.47	1.32 miles	7.93
April .....	32.46	3.00 miles	10.82
May .....	34.91	3.00 miles	11.64
*June .....	45.79	3.55 miles	12.90
July .....	27.94	2.50 miles	11.18
August .....	21.63	2.50 miles	8.65

The general plan of irrigation that is carried out here is quite similar to that used by other plantations, except that the beginning and end of the irrigation season is largely decided by means of soil moisture determinations. Irrigation commences in the spring as soon as the soil moisture has dropped appreciably below the optimum point in many of the fields. In the same way the season is closed in the fall, when the soil moisture has increased and the appearance of the cane indicates an adequate supply of water in the soil. During the irrigation season, as far as possible, the irrigation in each field is carried out by a regular series of rounds. The interval between rounds varies for each field and with each irrigation. No regular irrigation schedule has been worked out, as yet, and it does not seem practical to do so as conditions vary continually. In consequence of this variation, the water has to be put on where it is most needed and where the best results will be obtained. A very careful study of the individual fields has been necessary.

Growth measurements have been carried on in all the fields of the plantation, in conjunction with the measurement of the irrigation water applied. A typical series of these results is shown in Figs. 4, 5 and 6.

The conclusion has been reached from this work that the youngest fields should have the first consideration as far as irrigation is concerned, and so far excellent results have been obtained by following out this plan. By doing this a better stand of cane is obtained, the cane closes in more quickly, to shade the soil, which in turn helps to save considerable water, and there is every indication that the yield will be appreciably better.

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\* This figure was high due to the fact that the amount of water flowing through this ditch was comparatively small compared with other months and the water was used at a greater distance.

## WAIMANALO SUGAR COMPANY

Poor Field

Field 4.

Graphs showing the relation of water and temperature and its effect on the growth of cane. Three typical fields are shown, one poor, one medium, and one good.

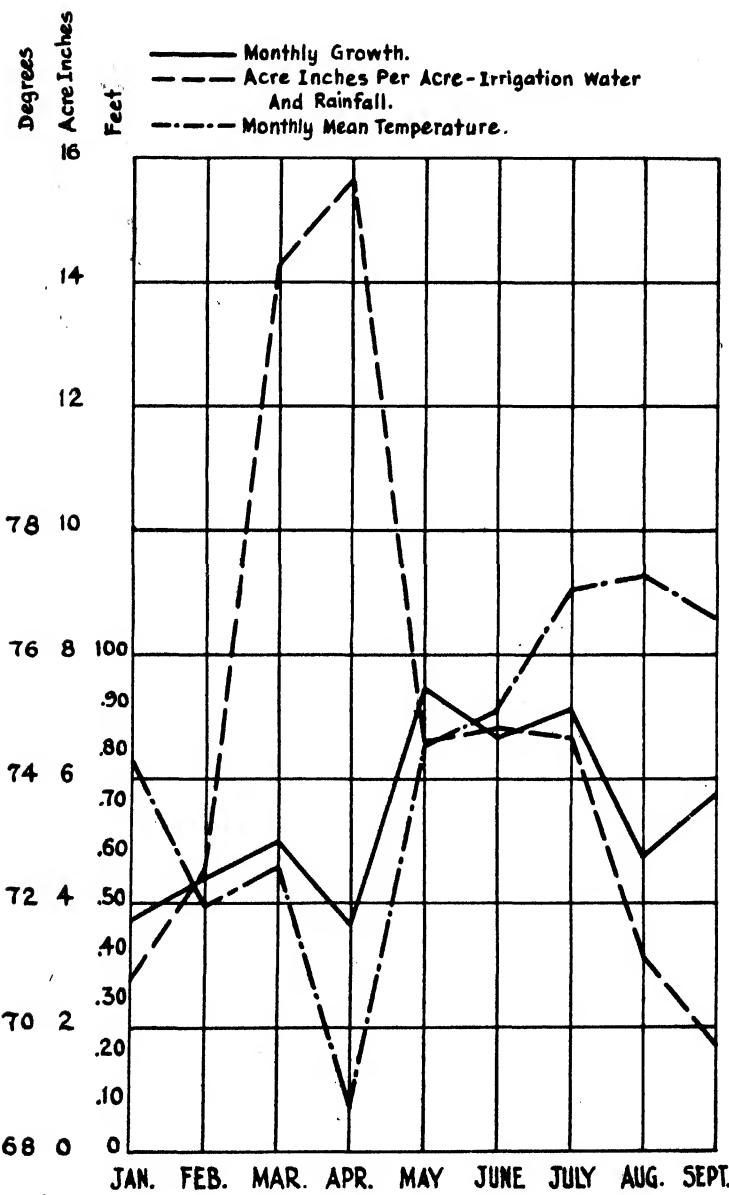


Fig. 4.

# WAIMANALO SUGAR COMPANY

Medium Good Field.

Field 27.

Graphs showing the relation of water and temperature and its effect on the growth of cane. Three typical fields are shown, one poor, one medium, and one good.

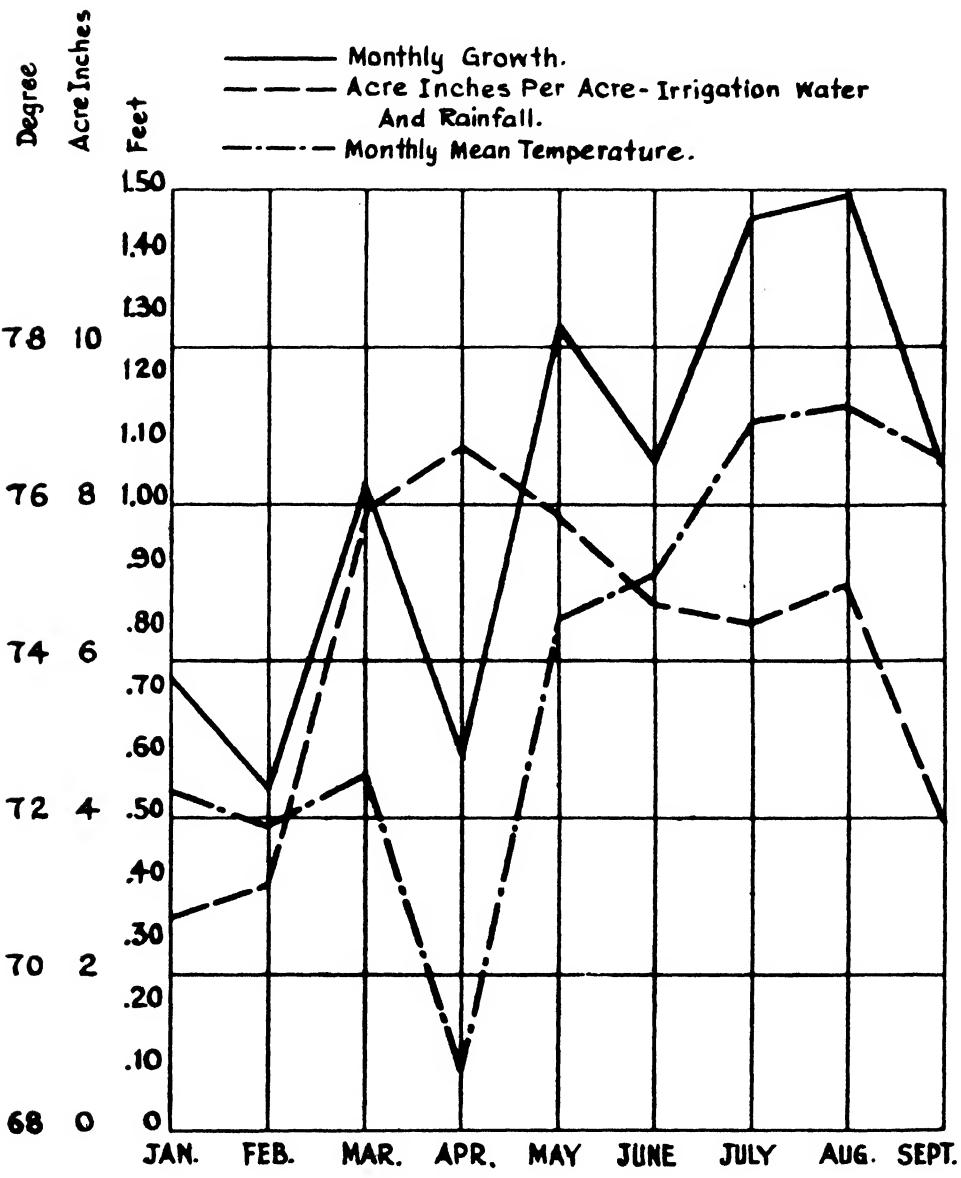


Fig. 5.

## WAIMANALO SUGAR COMPANY

Good Field. Field 26.

Graphs showing the relation of water and temperature and its effect on the growth of cane. Three typical fields are shown, one poor, one medium, and one good.

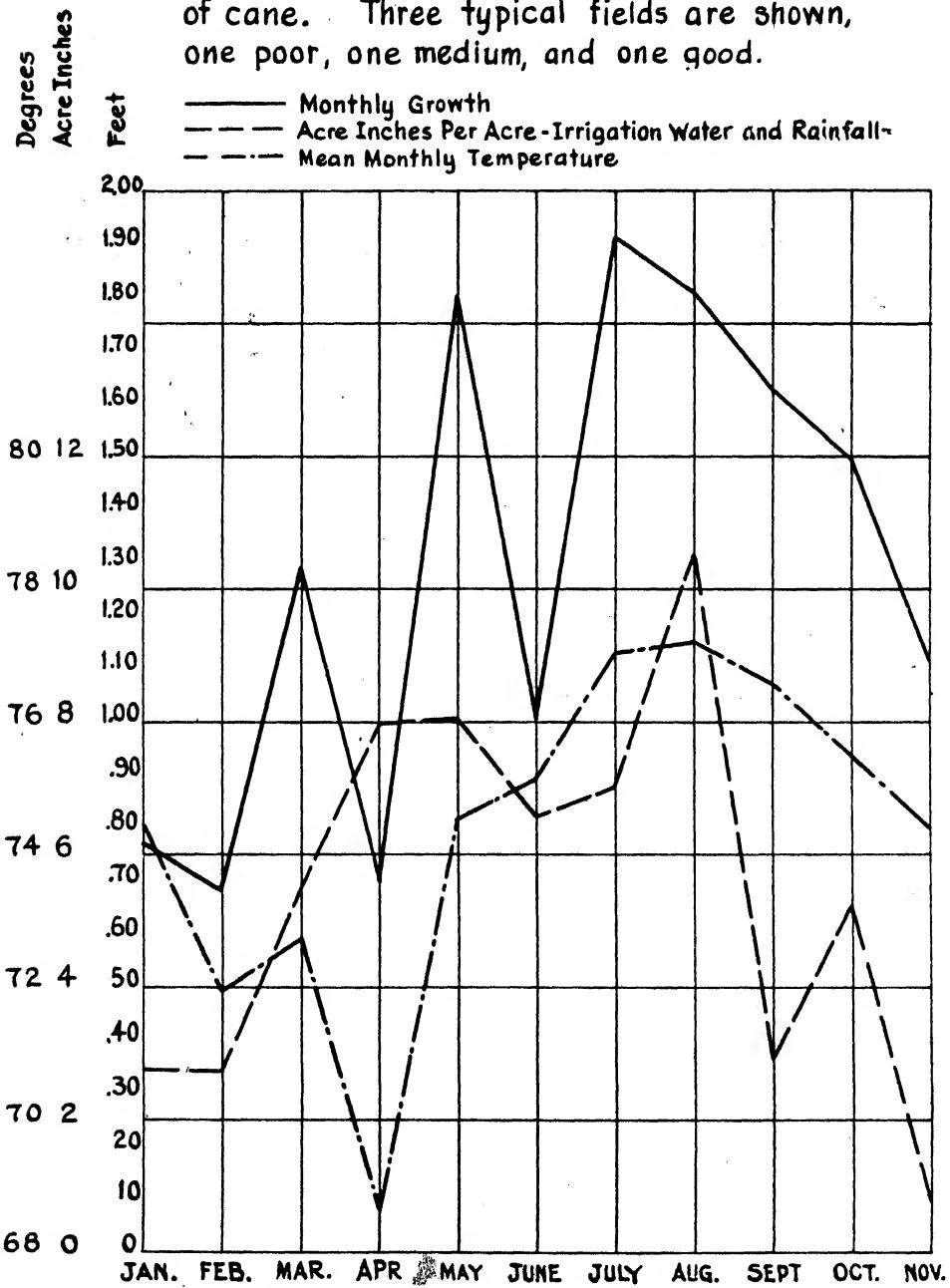


Fig. 6.

The following is a form of the data that are kept for each individual field and crop:

Field No.	Round No.	Total acres	Total Gallons	Total for round Man days	Age of cane	Gallons per Man day	Gallons per Acre	Acres per man day	Acres in. per man day acre
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When a round has been completed for any field the necessary data are immediately computed and compared with the previous report to see if there has been any improvement, particular attention being paid to the columns, Acres per Man Day, and Acre Inches per Man Day.

It has been found in carrying on this work that the amount of water that a man can handle economically per day varies considerably with the conditions under which he is working. A man, in order to do his work efficiently, needs a considerably larger stream of water in old cane than in a field that is about a foot high. Likewise he takes much less water in a young plant field than in a young ratoon field.

#### FIELD 13—1927 SHORT RATOONS

R.	Age months	Interval	Gallons per man per day	Gallons per acre	Acres per man day	Acre inches per man	Acre inches per acre
1	2	8	87,280	85,470	1.021	3.214	3.148
2	3	18	131,410	168,284	0.781	4.84	6.20
3	5	11	141,768	138,831	1.021	5.22	4.97
4	7	13	130,340	159,550	0.817	4.80	5.88
5	8	12	120,543	93,345	1.249	4.43	3.44
6	9	5	223,241	125,786	1.770	8.22	4.63

#### FIELD 23—1927 RATOONS

1	8	11	80,500	96,840	0.831	2.96	3.566
2	9	7	155,910	199,283	0.782	5.74	7.34
3	10	8	161,335	151,631	1.064	5.94	5.58
4	11	12	139,228	172,727	0.806	5.13	6.36
5	11	3	153,305	121,030	1.267	5.65	4.46
6	12	9	153,557	138,397	1.108	5.66	5.10

#### FIELD 24A—1927 RATOONS

1	8	23	127,129	262,895	0.484	4.682	8.682
2	9	17	171,818	203,034	0.846	6.328	7.477
3	11	22	112,333	146,016	0.769	4.14	5.38
4	13	20	196,677	180,170	1.059	7.24	6.63
5	13	18	257,136	197,505	1.302	9.47	7.27
6	14	26	250,126	295,570	0.846	9.21	10.88

The above tables show round reports for three typical fields and crops. Fields 13 and 23 are ideal fields of a black loamy type of soil with a high water-holding capacity. Field 24A has a coral subsoil and is a very open soil. This brings out the relation between the amounts of water applied per acre per round, the age of cane, and the interval, very clearly. The amount of water required per acre round is much less in small cane than in large cane.

## THE ARRANGEMENT OF A CROPPING CYCLE IN RELATION TO WATER ECONOMY

The problem of harvesting crops at the best time and with a view to economically applying the limited water supply to the growing crops to the best advantage, or, in other words, to get the maximum duty of the available water, has been a most difficult one to solve. A plan whereby every weather condition can be taken advantage of in helping the younger crops along has been drawn up and seems to be a very good one. This cropping cycle, as it might be called, is divided into three periods and is as follows:

The harvesting of those fields which are to be short cropped is begun about the first of November and continued through into February. This harvesting will cover an area of some four hundred acres. Here a shutdown period is introduced in order to prepare these fields and clean up any other fields that need attention. When harvesting is again started, those fields which are to be plowed and planted or long cropped, are taken off. This second period will be slightly longer than the first and about six hundred acres will comprise the area to be harvested. After this a short time is taken up in conditioning the fields. In the last grinding period approximately four hundred acres of short crops are harvested yearly.

By studying this schedule it will be seen that during the month of our water shortage, which is September, the smallest area occurs under irrigation. By starting harvesting the latter part of the year the early rains are utilized to start the new crops.

The saving in water by short cropping is pretty well brought out by the data obtained during the crop of 1926. Of course a certain amount of data had to be assumed. Actual figures will be obtainable at the end of the 1927 crop.

### Crop 1926

	Long ratoons	Short ratoons
Tons cane per acre.....	58.27	51.03
Quality ratio .....	9.19	8.70
Tons sugar per acre.....	6.34	5.86
Average age, months.....	21.0	16.0
Tons sugar per acre per month.....	0.302	0.366
Gallons water applied per acre.....	1,672,300	1,371,700
Gallons water per ton sugar.....	263,700	227,480
Tons sugar per million gallons.....	3.79	4.27

These data do not include the rainfall.

### SUGAR PRODUCED PER MILLION GALLONS OF WATER

Since approximately the same amount of irrigation water is used each year it will be safe in assuming that the total amount of irrigation water used during the year 1925 would be the amount of water used to produce 7,814.69 tons of sugar. Sugar produced per million gallons of irrigation water for this crop was 3.76 tons.

From irrigation experiments conducted during 1924 and 1925 it has been found that on the "plantation practice" plots one million gallons of irrigation water produced 5.16 tons of sugar on one plot and 11.51 tons of sugar on another. These two plots, however, represented two types of soil of very different characters, the former being a reddish type and very porous with a relatively low water-holding capacity, and the latter a heavy black loam type with a relatively high water-holding capacity.

### EXPERIMENTS

The irrigation experiment that was carried on in Field 15 was continued into the ratoon crop and will be harvested again in 1927. The acreage was increased to include 7 plots of approximately one acre each. Two plots are receiving irrigation every two weeks; two plots receive irrigation once a month and the three check plots receive the regular plantation irrigation. All of the plots received uniform fertilization, so that any gain can be attributed to the irrigation methods. The growth curves show a considerable increase in favor of the extra irrigated plots and there is every indication that there will be an increase in yield on these plots.

An irrigation test on the method of irrigation used here was conducted over a short interval and may be of some interest. Two irrigations were made using the regular Hawaiian system. One irrigation was made to change from the Hawaiian method to the method used here, and then two irrigations were conducted the same way irrigation is conducted here. Time cards and the amount of water used under the two systems were kept. The same men were used to irrigate the same areas under both tests.

### COMPARISON OF METHODS OF IRRIGATING

(1) Hawaiian furrow system, every row irrigated, one irrigation up the watercourse and one irrigation down, compared with (2) system used at Waimanalo, two irrigations down and up.

Irrigation	No. of men	Acres covered	(1)			
			Time per irrigation	Total gal- lons used	Acre inches per acre applied	Acres per man day
First up .....	3	0.933	3.58 hrs.	68,640	2.55	0.869
Second down .....	2	0.933	5.08 hrs.	71,330	2.65	0.918
(2)						
First down and up....	1	0.933	4.58 hrs.	58,760	2.18	2.037
Second down and up..	2	0.933	2.75 hrs.	44,090	1.64	1.697

The system used at Waimanalo, contrasted to the usual Hawaiian practice, is represented in Fig. 7. In the Waimanalo modification, the irrigator going down the furrow is irrigating the odd-numbered furrows 1, 3, 5, etc. Coming back up the watercourse, he will irrigate the even-numbered furrows 20, 18, 16, etc. This plan is believed to possess several advantages, besides covering a greater area

# HAWAIIAN FURROW SYSTEM

## EVERY ROW IRRIGATED

### WAIMANALO MODIFICATION

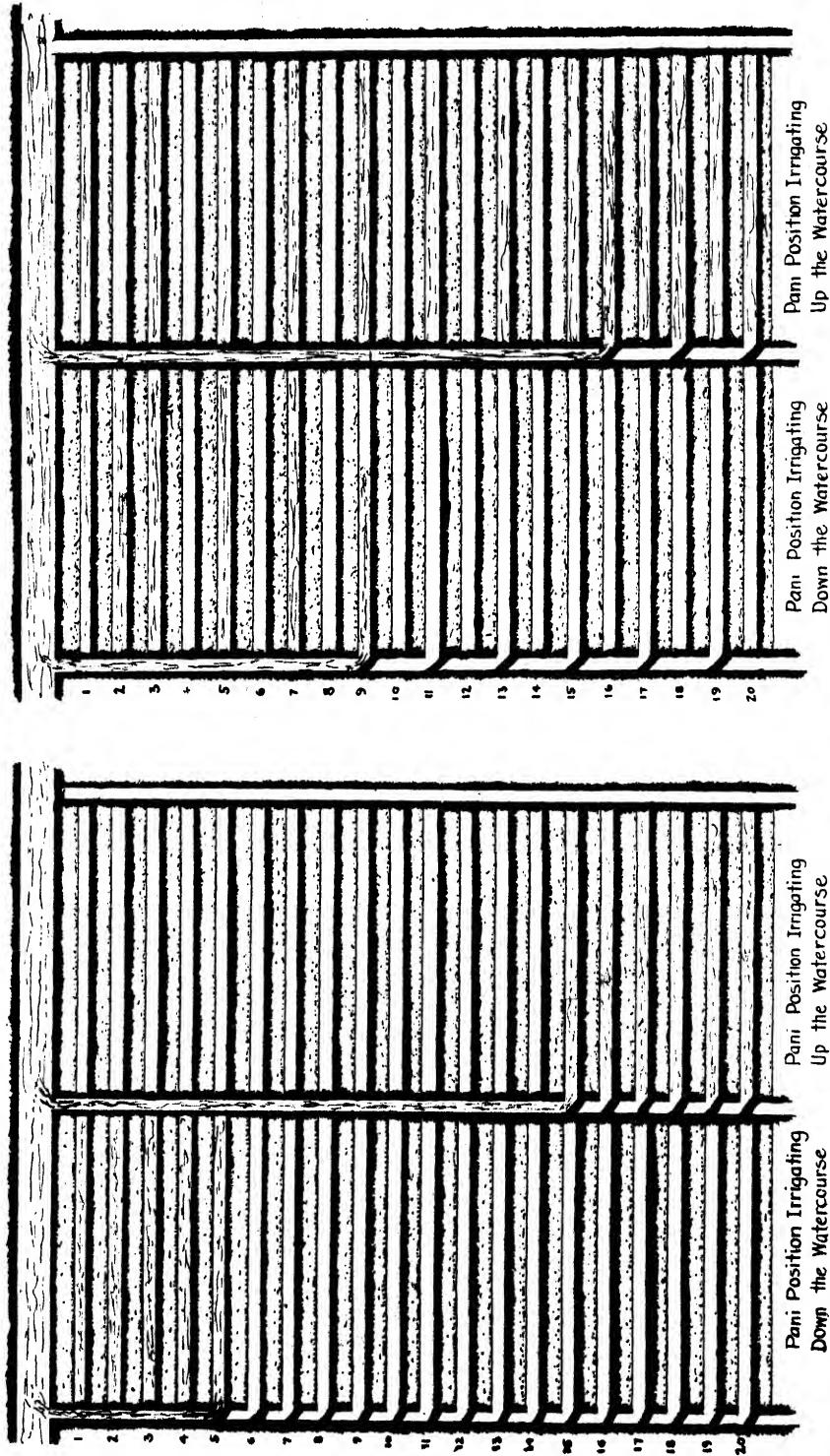
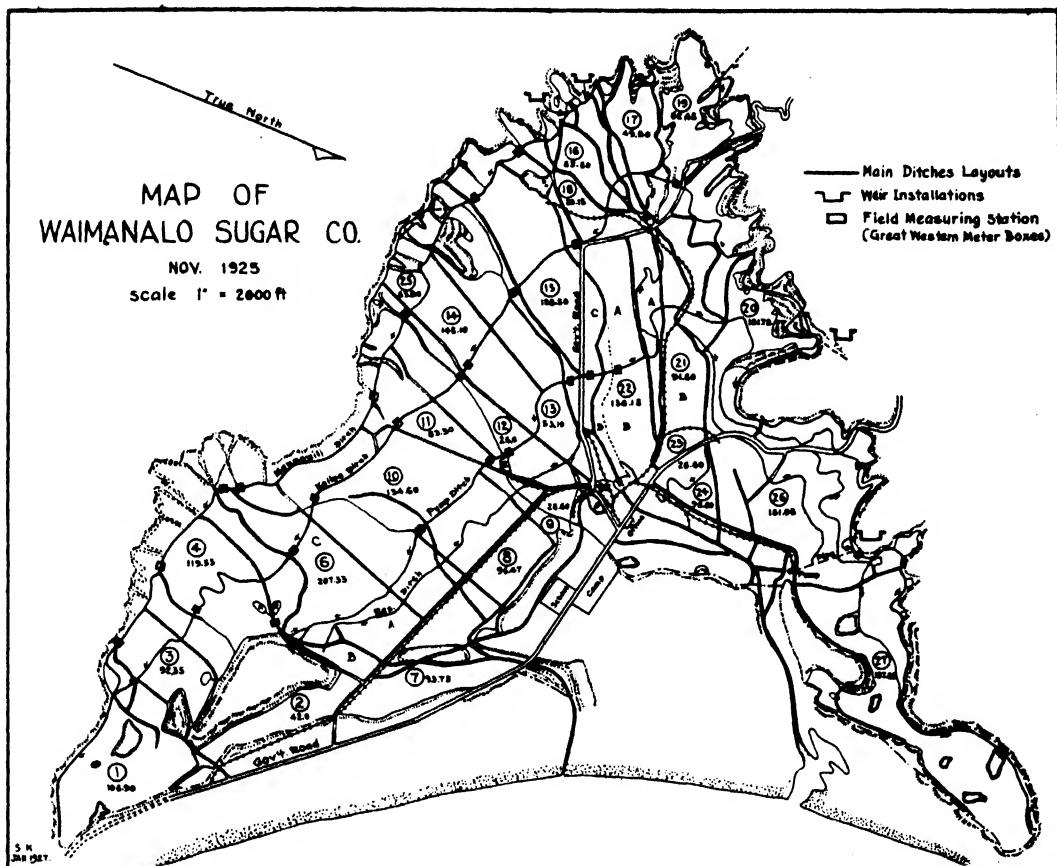


Fig. 7. Sketch showing the modification of the Hawaiian furrow system of irrigating that is being used with such good results at Waimanalo.

as indicated in the preceding test. It has been found quite advantageous to leave the panis in place in the watercourse at alternate lines. Such an arrangement prevents washing of watercourses during heavy rains or when water is accidentally turned into the level ditches or watercourses.

#### THE COST OF WATER MEASUREMENTS

Most plantations, before starting work of this type, will be interested, primarily, in the cost of water measurements. The initial cost of this work, if undertaken on a large scale, will be enough to make any one hesitate before starting



## INITIAL COST

Meter and installation for five years.....	\$ 70.00
Supervision and care of meter for five years.....	113.40
Total cost per meter for five years.....	\$ 183.40

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Cost per year.....	36.68

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Assuming that a man irrigating handles 150,000 gallons per day and irrigates 200 days a year, he will handle in five years 150,000,000 gallons of water. If the cost per million gallons of water is \$20.00 and a man's efficiency is increased 20 per cent there will be a saving as follows:

150 million gallons of water @ \$20.00.....	\$3,000.00
20% saving for five years.....	600.00
Saving resulting from meter installation for five years.....	\$ 600.00
Cost per meter for five years.....	183.40
Net saving for five years.....	\$ 416.60

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A 20 per cent saving is assumed to try and meet average conditions. In actual practice, the increase in efficiency was nearer 50 per cent.

## SUGGESTIONS FOR EFFICIENCY IN IRRIGATION

In studying the irrigation problem here, several important phases of the work have stood out very prominently as producing efficiency in irrigation practice. These are:

- (1) Making careful measurements of the water as it goes on the fields.
  - (2) Making round reports of the water used per man, the amount applied per acre and the area covered per man day.
  - (3) Giving the irrigators, at all times, the maximum amount of water that they can handle efficiently.
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**Hawaiian Agriculture Prior to 1860\***


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COMPILED BY H. P. AGEE

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Until the development of the pineapple industry within recent years, the prosperity of Hawaii, as we all know, was largely dependent upon sugar. Some students of agriculture are inclined to question the soundness of such one-crop agriculture. It is of some interest therefore to know from what a diversity of

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\* Read at a meeting of the Social Science Club, Honolulu, November, 1926.

agricultural effort a sugar industry grew, and what a painful process it was, fraught with struggle, discouragement and failure all along the way.

Fortunately, many details of the early agriculture of the Islands are preserved for us in the *Transactions of the Royal Hawaiian Agricultural Society*, which held annual meetings between 1850 and 1856, inclusive. The membership of that organization included progressive, farsighted men. Some of their predictions are remarkably accurate. In laying plans for the future they reviewed the past.

Since so much of the charm of history may be lost when one attempts to change the wording of old documents into language of his own, I shall, for the most part, use direct quotations from the original papers. One of particular interest is the address of R. C. Wyllie, delivered at the first convention of the Society in August, 1850. From it I read:

We are now in a position duly to appreciate the great benefits conferred on the nation by the introduction of seeds, plants and animals, by those who have gone before us.

In running through the pages of Captain Cook, we find the following productions, only, of the Islands seventy-two years ago, viz:

Taro of large size and fine quality.

Sweet potatoes, from 12 to 14 pounds each.

Plantains, five or six varieties.

Bread fruit; scarce.

Yams; scarce.

A sweet root like a yam in form; probably the root of the ti plant.

Sugar cane of large size and good quality.

Cocoa nuts.

Ava root.

Gourds.

Fowls; scarce.

Hogs; abundant.

Dogs; used as food.

Geese.

Large white pigeons.

Fourteen years afterward, or fifty-eight years ago, when Vancouver visited the Islands, we find that the following were the only new productions, viz: Goats, Water Melons, Musk Melons.

Since those days the productions of the Islands have become wonderfully multiplied, and their wealth has increased in proportion. I have taken some pains to learn to whom the Islands are indebted for this great and beneficial change. They are as follows:

1. The discoverer, Capt. Cook, who, on Sunday, the first of February, 1778, left on the Island of Niihau, one ram goat and two ewes, a boar and sow of English breed, and the seeds of melons, pumpkins, and onions.

2. Captain Colnet, who left a ewe and a ram on Kauai, before the arrival of Vancouver.

3. Captain Vancouver, who, on Sunday, the fourth of March, 1792, left to Tianna on Hawaii, some vine and orange plants, some almonds and garden seeds, and to Keau-moku (the father of Kaahumanu) a goat and kid, some fine orange plants and garden seeds. On the 13th of March, 1792, he left to the young Prince Kaumualii, of Kauai, a male and female goat and two geese; on the 25th February, 1793, he left to Keau-moku, before mentioned, one ram, two ewes and one ewe lamb; on the 19th February, 1793, he landed a bull and cow from California, for Kamehameha I, in the canoe of Krimamahoo, off the coast of Hawaii; on the 22nd of February, 1793, he landed five cows, two ewes and

a ram, in the bay of Kealakekua, for Kamehameha I; on Tuesday, the 5th of March, 1793, he landed in the same place, for the King, a variety of culinary utensils, implements of husbandry, smiths' and carpenter's tools; on the 17th of March, 1793, he presented a large assortment of useful tools, implements and household utensils, and some goats to the king of Maui; on the 28th of March, 1793, he presented a complete set of armorer's tools to Enemo, the ruling chief of Kauai; on the 15th of January, 1794, he landed a bull, two cows, two bull calves, five rams, and five ewe sheep, from California, in Kealakekua Bay, for Kamehameha I.

4. Don Francisco de Paula Marin, who came to the Islands at a very early period (it is believed in the Princesa Real, in 1791), and who appears to have served the King in many capacities. His journal, kept in Spanish, and consisting of several volumes, is in my possession. The volumes are much dilapidated, and as the first entry is dated 14th November, 1809, there is reason to believe that several volumes have been lost. I have hastily extracted the following particulars from his journal:

On the 11th of January, 1813, Marin says he had planted at sundry times, some pine apples and an orange tree, beans, cabbages, potatoes, peaches, chirimoyas, horse radish, melons, tobacco, carrots, asparagus, maize, fig trees, lemons, lettuce, and that he had been engaged in making kukui oil, cocoa nut oil, candles, tiles, hay, cigars, and had acted in the several capacities of butcher, cook, mason, ship carpenter and physician;

On the 27th of June, 1813, he was engaged in making nails;

On the 24th of February and 1st of March, 1815, he was engaged in planting vines for the King;

On the 6th of July, 1815, it is recorded that he made 38 gallons of wine;

On the 13th July, 1815, that he made five flasks of brandy;

On the 7th of December, 1815, that he made a barrel of beer;

On the 30th of December, 1817, there is a record that he planted coffee, cotton, made lime, planted cloves, salted pork, made pickles, planted tomatoes, turnips, pepper and chilis, sow'd wheat and barley, made castor oil, soap, molasses, syrup of lemon juice, planted saffron, cherries, and made shirts;

On the 25th of February, 1819, he was engaged in making sugar;

On the 15th of April, 1819, that he was sent for to cure the King, with whom he remained till the 8th of May, when he says, the King died, aged 60 years and 6 months;

On the 18th of May, 1819, that he was repairing muskets;

On the 27th of August, 1819, that he was selling vegetables for the King to the French sloop of war "Descubierta;"

On the 14th of September, that he was making extensive purchases from vessels, for the King.

On the 22d of September, 1819, he says: "This day they brought me the first orange, though I planted the seeds eight years ago."

On the 4th of November, 1819, that he was engaged bartering sandal wood for rum;

On the 8th of December, 1819, that he received the commission of Captain, which commission is still extant;

On the 14th of March, 1820, he records, "this day arrived the brig of middling size, called the Thaddeus, Capt. Blanchard, bringing missionaries for these Islands."

From this brief account of the labors of Don Francisco de Paula Marin, from 1809 to 1820, few of you will doubt that much of the present wealth of the Islands, is owing to seeds, roots, and plants introduced by that one man. In my own opinion, it may be fairly questioned if there existed on these Islands, or exists at present, any man, to whom the Hawaiian people are generally so much indebted. His surviving children, therefore, are well entitled to the favorable consideration of the King's Government.

It is true that Marin was more frequently engaged in distilling brandy, rum and beer, than I have thought it worth while to record. But, nevertheless, he seems to have been, upon the whole, a temperate man, for, from 1809 to the 14th of March, 1820, he only records that he was drunk on three occasions, on one of which they had to carry

him home. If he had been oftener drunk, I have no doubt he would have mentioned it, for his journal is singularly minute in regard to his private habits, and those of the King and the ladies of his family. It is due to his memory to mention, that amongst his papers were found some ancient translations into native of the Lord's prayer, and other prayers used by the Catholics, from which it is to be inferred that he had made some effort to abolish the native idolatry.

It will be noted that Marin told that he made sugar on February 25, 1817. This is one of the earliest records of sugar making, but not the first, for there is evidence, but not positive proof, that sugar was made on Lanai in 1802. Of this and some other early endeavors Thrum, in his Annual for 1875, says:

There are many localities laying claim to the first mill, and as many claiming the credit for the establishment of this industry, which has long since been the leading one, that it has been no easy task to define its legitimate founder. After examination through all the early publications of the Islands for definite authority and a starting point, the only information thereon is found in a paper read by the late L. L. Torbert before the Royal Hawaiian Agricultural Society, in January, 1852, wherein he states that "the earliest sugar manufacture was in 1802, by a Chinaman, on the island of Lanai, who came here in one of the vessels trading for sandal wood, bringing with him a stone mill and boilers, and after grinding off one small crop and making it into sugar, went back the next year with his apparatus." Mr. Torbert gave as his authority, John White, who arrived at the Islands in 1797, and who, from his constant travel back and forth in the retinue of the chiefs, had ample opportunity to learn of the time and place of the new industry.

The fact of Mr. Torbert giving credence to the above, and his presenting the same before the Agricultural Society, is proof sufficient in the minds of many that the same is correct; yet there are a large number who place no reliance on the statement, and look to a later period for its establishment.

As before stated, various localities lay claim to the first established mill, or more properly, the first manufacturing of sugar, for sugar and molasses were produced before the establishment of a mill.

Don Paulo Marin recorded in his journal of making sugar in Honolulu in February, 1818, but no allusion other than this is made thereto.

Sugar was made in Honolulu about 1823, by Lavinia, an Italian, who had the cane pounded or mashed on huge wooden trays (poi boards) by natives with stone-beaters, collecting the juice and boiling it in a small copper kettle. About this same time Antone Catalina is also claimed by some to have been the founder of the industry by making excellent syrup at Waikapu, Maui—the site of the present Waikapu Mill—and Jungtai, a Chinaman, is said to have established the first mill at Wailuku.

Various accounts agree as to the manufacture of sugar and molasses being entered into quite generally about this time (1823-4), though doubtless with the view of rum making, which was then carried on extensively.

Stephen Reynolds, in a paper entitled "Reminiscences of Hawaiian Agriculture," read before the Royal Hawaiian Agricultural Society, in 1850, gave an account of the first serious attempt to start a plantation. This paper reads:

Coffee plants were introduced by Lord Byron in the "Blonde" in 1825. If the plant had been introduced here before, it had become extinct. These plants were taken on board at Rio Janeiro.

In an agricultural and commercial view, cane and coffee are most important—for food, the Kalo. Experience has proved thus far that the soil and climate are favorable to the coffee tree, to the growing of cane and manufacture of sugar.

The first enterprise to any extent to start a plantation on these Islands, was undertaken by Mr. John Wilkinson, who came from England under the patronage of Governor Boki, when Lord Byron in the "Blonde" brought Governor Boki and his party back to the Islands, and the remains of the King and Queen who died in London.

Mr. Wilkinson had made partial arrangements with Governor Boki while in England, to be completed here. Manoa valley was selected as an eligible situation, and a suitable soil for a coffee and sugar plantation. The documents were made out and operations began. Mr. Wilkinson, unfortunately, had but small funds which were soon expended. He began on a large scale—laid out a large garden in a most fanciful and tasteful manner. He commenced operations in July or August, 1825. Every kind of farming utensil was wanted—not to be had—to carry on so great an undertaking. Carts, ploughs, hoes—all were very scarce. Expedients had to be resorted to. The land was mostly prepared by natives with the oo or digger, a long and costly process, for a speedy operation. Labor at 25 cents per day soon exhausted the planter's funds. He was sickly, and died March, 1827. He had more than one hundred acres of cane growing when he died. Governor Boki was desirous to save it. Mr. Wm. French, John C. Jones, Esq., John Ebbets and myself took an interest in the plantation. After the first cutting, the plantation dilapidated and wasted away for want of protection. The coffee trees were left to grow without care or attention. Small parcels were picked by the natives, a pound or two at a time. Whether the same trees are still growing I do not know. Alexander Adams planted some slips in Kalihi valley that produced excellent coffee. Also at Niu, a valley beyond Diamond Hill. Rev. Joseph Goodrich introduced coffee plants at Hilo, which grew luxuriantly. There were two kinds, the large white and the dark berry—similar to that now cultivated at Hilo. Some plants were introduced on the west side of Hawaii, which grew and produced largely, demonstrating most clearly that it was well adapted to that part of the island. The plantations of Mr. Charles Titcomb, and Mr. Godfrey Rhodes, on the island of Kauai, give complete evidence that coffee of superior quality grows on that island, yielding large crops.

Again turning to Mr. Thrums paper previously mentioned, we read:

That the various sugar mills so far were but small and primitive, and the cultivation of cane but little attended to, may be inferred from there being no notice made thereof, and on this account, perhaps, our historian, Jarves, did not touch upon this subject in his history of the Islands, though he had ample means in his day (1840) of learning the full facts of its origin and growth.

In view of the foregoing facts, we must, without doubt, give credit to Messrs. Ladd and Company, for the bona fide establishment of sugar manufacture, who, in 1835, secured a grant of land at Koloa, Kauai, from the Government, for silk and sugar culture.

It is to Dr. R. W. Wood that we owe a detailed account of this enterprise. The Royal Hawaiian Agricultural Society had asked him to give an "Historical Account of the Introduction and Progressive Culture and Manufacture of Sugar in these Islands." Pleading lack of time and necessary data he confined himself largely to the single plantation at Koloa:

It is known to most of the older residents, that about the year 1835, a mercantile house in Honolulu obtained, with no little difficulty, a grant of land, on the Island of Kauai, for the purpose of establishing a sugar plantation. Previous to this period some attempts had been made to introduce this branch of industry, but that which has been already alluded to by Mr. Reynolds, is the only one deserving of notice, and that not promising to be productive, was soon abandoned. That on Kauai was the first enterprise of any magnitude of this kind, on the Sandwich Islands. For a period of six years subsequent to its commencement, its failure continued to be confidently predicted by the more intelligent portion of the foreign community.

On this plantation the ground was first broken by a plough drawn by natives. There were no working cattle at that time upon the Island. Wild or indigenous canes, abundant in the vicinity of Koloa, after three or four months persevering resistance of the prohibition of use imposed upon them by the Chiefs of Kauai, were collected, and a nursery commenced. From the first crop of cane obtained, the proprietors succeeded in producing molasses or syrup only. The following season they succeeded in producing sugar, but of inferior quality, and the sugars produced from that estate previously to the year 1842, would now be considered scarcely merchantable.

Previous to the year 1840, two mill sites were abandoned, and the entire works, including buildings, machinery and furnaces sacrificed. A third mill was erected in 1841, which, with improved works, enabled the proprietors to increase considerably the products of their estate, with however but very little, if any, improvement in the quality of the sugars manufactured.

About this time a French gentleman, M. Provost, who had had considerable experience in the manufacture of sugar in the Isle of Bourbon, was engaged upon the estate for the period of one year. In consequence of the improvement introduced by him in the tempering, clarifying, boiling and granulating of sugars, their quality was greatly improved, and their value increased. Previous to the year 1843, in the absence of purchasers, and for the want of nearer markets, the proprietors were under the necessity of shipping, on their own account their sugars, to Valparaiso, Sydney, and the United States, and they sustained by these operations, a loss of some thirty thousand dollars. Since the year 1843, very little, if any, advance has been made in the improved quality of sugars, although the aggregate quantity produced upon the Islands, has been yearly increasing. Although the present mode of conducting its manufacture is of great improvement upon the rude and unskillful attempts of the pioneers in this branch of industry, yet, owing to the want of better constructed works, and of more skill and experience in constructing them, the business is still prosecuted under comparatively great disadvantages. And thus far the Sandwich Island planters, have been less indebted for their success, to the efficiency of their mills and boiling houses, than they have been to the excellent adaptation of soil and climate to the culture of the cane, to the proximity of good markets, and especially to their exemption from competition with more systematic and skillful manufacturers. In proof of this assertion, I need but refer to the statement made by Mr. Parsons, that it has been ascertained, by a nice calculation, that on a plantation on Maui, the cost of growing was about twelve dollars, and that of manufacturing fifty dollars per ton; which in Demerara, the East and West Indies, the cost of growing and manufacturing is considered about equal. It is true that in some of these countries, especially Demerara, where the land requires to be drained by canals intersecting each other in every direction, and where only the spade and hoe can be used, the culture of cane is attended with more expense, than it is in the light mellow soil of these Islands. Still the cost of manufacturing ought not much to exceed that of growing the cane.

Concerning subsequent endeavors, Thrum says:

Notwithstanding the difficulties under which this plantation was working, and the prophecies of many for its failure, it gave an impetus to others in various parts of the Islands, for in 1838 there were in operation, and about to be erected, twenty mills by animal power and two by water power.

Previous to 1841, probably 1839, Governor Kuakini, of Hawaii, had a few fields of cane planted at North Kohala, about 75 or 100 acres in extent, with the expectation of a contract with some foreigner for grinding.

In 1841 thatched buildings were put up in Iole, Kohala, by the Governor, in pursuance of an agreement with Aiko, a Chinaman, who had previously followed the sea in some capacity under Capt. Brewer. Aiko himself followed immediately and put up his mill—upright wooden rollers, 18 inches in diameter, by two and one-half feet high bound with iron,—and an over-shot water wheel for motive power. The planting was done by

contract with natives in the old style, i. e., with an oo, digging off the grass and making the least bit of a hole possible for the seed. Labor was cheap and paid for in goods. Brown cotton at \$1.00 per pio (3 yards) and blue cotton and prints at \$1.50 for the same quantity.

The products of the mill were laboriously carted over the hills to Mahukona where they were shipped to Honolulu. The carts were very heavy and the wheels were cross sections of koa logs. The wear and tear therefore of oxen and carts over the rocky road were very great. Nevertheless the proprietor was successful in making money and would have remained, but the heir of Governor Kuakini so increased the rents of lands and other charges that he threw the whole thing up in disgust and left for Hilo, where he carried on a plantation with success for many years, and where he now resides.

Before leaving, however, he sold out his plantation to an invalid Chinaman. The latter deceased soon after and the establishment came back upon Aiko's hands and he returned, ground the last crop, and definitely closed up the business in 1849 or 50.

Up to 1843, Hawaiian sugars did not enjoy a favorable reputation abroad, partly from the low grades, but more from the injudicious desire of many producers to realize all possible. Sugars were shipped imperfectly cured, and in several cases all the refuse was added thereto that could be collected from the drying-houses; nor was our reputation thoroughly established for good merchantable sugars until after the establishment of the Royal Hawaiian Agricultural Society in 1851, when their attention was called to the fact, and their influence sought thereon.

The first notice made of any exportation is for the year 1837, when 4,286 lbs. sugar and 2,700 gals. molasses were exported. A regular table from this point being valuable and interesting, we have compiled the following, but as this was prior to the establishment of Customs' regulations at these Islands, the figures we have are from merchants published statements and are not fully complete—as the notings herewith show:

#### YEARLY REPORTS OF SUGAR AND MOLASSES FROM THE HAWAIIAN ISLANDS SINCE 1837—ITS FIRST YEAR OF EXPORTATION

Year	Sugar pounds	Molasses gallons	Year	Sugar pounds	Molasses gallons
1837 . . . . .	4,286	2,700	1856 . . . . .	554,805	58,842
1838 . . . . .	88,543	11,500	1857 . . . . .	700,556	48,486
1839 . . . . .	100,000	75,000	1858 . . . . .	1,204,061	75,181
1840 . . . . .	360,000	31,739	1859 . . . . .	1,825,620	87,513
1841 . . . . .	60,000	6,000	1860 . . . . .	1,444,271	108,613
1842 . . . . .	.....	.....	1861 . . . . .	2,562,498	128,259
1843 . . . . .	1,145,010	64,320	1862 . . . . .	3,005,603	130,445
1844 . . . . .	513,684	27,026	1863 . . . . .	5,292,121	114,413
1845 . . . . .	302,114	19,353	1864 . . . . .	10,414,441	340,436
1846 . . . . .	300,000	16,000	1865 . . . . .	15,318,097	542,819
1847 . . . . .	594,816	17,928	1866 . . . . .	17,729,161	851,795
1848 . . . . .	499,533	28,978	1867 . . . . .	17,127,187	544,994
1849 . . . . .	653,820	41,235	1868 . . . . .	18,312,926	492,839
1850 . . . . .	750,238	129,432	1869 . . . . .	18,302,110	338,311
1851 . . . . .	21,030	43,742	1870 . . . . .	18,783,639	216,662
1852 . . . . .	699,170	62,030	1871 . . . . .	21,760,773	271,291
1853 . . . . .	642,746	75,769	1872 . . . . .	16,995,402	192,105
1854 . . . . .	575,777	68,372	1873 . . . . .	23,129,101	146,459
1855 . . . . .	289,908	38,304	1874 . . . . .	24,566,611	90,060

These figures are from January to August only, while for 1841 the figures are from August, 1840, to August, 1841. No figures for 1842-1843, but the figures of the following year doubtless include both.

Sugar, its culture and manufacture, received considerable care and attention from the R. H. A. S., and doubtless, as much the object of its being brought into existence, as anything else was, to devise ways and means to promote this industry, as the published papers of the Society will show. That it has done so is plainly to be seen, for immediately following is noted an improvement in cultivation, grinding, boiling, draining, packing, etc., to say nothing of the increased interest taken in it and the impetus it received thereby from many who had been giving their attention to the whaling interests.

In a paper read before the Society in January, 1852, by the late L. L. Torbert, he stated that "cane grew without culture, almost anywhere on these Islands, as high as 3,000 feet. At 1,700 feet above the sea it ceases to blossom and continues to grow on from year to year for four, five or six years. How long it will grow on the same spot without exhausting the soil would be hard to tell, as he knew of a field, that according to the tradition connected therewith, must have been one hundred years old, and bid fair to produce equally good canes as many years hence. In some soils it may degenerate and die out, while in others it improves by long standing."

During the season of 1851, the first centrifugal drying machine was put in operation at the East Maui Plantation. Previously all sugars were dried by the old and tedious process of draining from boxes or barrels, through holes bored to allow the molasses to drain off, leaving it but imperfectly or unevenly dried after all. The centrifugal gave such universal satisfaction through the improved grades of sugar and the saving of time, that it made a thorough revolution in our sugar industry, for every planter, large and small, changed as fast as their orders could be filled.

The sugar interest suffered severely this year from an unprecedented drought, and was further checked by low prices on the Pacific Coast and the establishment of duties. These combined causes resulted in a great falling off in product, as we find but 21,030 pounds exported for 1851, the smallest amount since the first year of its exportation, and the tables up to 1855 show an unsteady yield, partly from the above causes and the inefficiency of labor, but after which the total yearly product has shown a steady gain.

Scarcity of labor was seriously felt on nearly all the plantations, but more especially on those of Kauai and Maui, and an effort was made to meet the difficulty by the importation of coolie labor from China, in 1852, to work under contract for five years. This for a time gave relief, but did not come up to expectations, for when working with the natives there were continued jealousies, and when their time was out they preferred to enter the trading or domestic service, to renewing a plantation contract. Labor was a vexed question in 1851, and it has continued to be so ever since.

An account of the first attempt to import Chinese labor is given in the report of the Committee on Labor at the 1851 convention of the Royal Hawaiian Agricultural Society. It reads:

A contract was entered into in the month of September, 1850, with G. F. Hubertson, Esq., a merchant recently established here (who had resided in China, and was supposed to be the best person with whom to make the contract, from his experience in the matter, and his facilities), for the importation of two hundred Chinese coolies. The charge for the passage for each coolie was fifty dollars, which with the advances to be made to each, on shipping them, and a year's supply of rice for consumption here, made the sum about \$71 that each coolie would cost delivered here, of which two months' advance wages formed a part. The men were to be engaged for five years. To secure dispatch in this matter between nine and ten thousand dollars, or nearly two-thirds of the whole amount was advanced to Mr. Hubertson to meet the ship's disbursements in China and the necessary expenses of shipping the coolies. The ship Amazon, belonging to Mr. Hubertson, sailed on the ..... and your committee believed that a successful commencement had been made of the great work to supply the islands with laborers, whose brawny arms should lay open to them the wealth now buried in its soil. But we were

sadly disappointed. The Amazon arrived in China, and the coolies, we learn, were engaged, but after waiting in vain for her return with the much needed freight, a rumor has reached us that the vessel has been sold and the voyage abandoned. The reasons for this disastrous result have not been made known to us, and in the absence of Mr. Hubertson we must probably for the present remain in ignorance of them.

Arrangements have since been made by members of this Society to produce coolies, with Capt. John Cass of ship Thetis, which vessel sailed yesterday for Amoy, for that purpose. This new enterprise your committee believe will be successful, and that we shall soon be able to try an experiment, the success of which will remove the grand obstacle to our agricultural progress and success.

In the first part of the same report an interesting reference is made to steam, the great new motive power which was yet to be made use of in the Islands:

That great auxiliary to, and substitute for, the labor of human hands, which is now lending its giant aid, not only to the mechanic and the manufacturer, but also the planter and the farmer, is as yet unknown among us. Not a steam engine is to be found upon these islands, and even the occasional visits of the "moku ahi," or fire-vessel, are yet hailed with wonder and admiration by the natives, and as "remarkable events" by the foreign class of our population. Doubtless this mighty agent will ere long be introduced and put in successful operation, but the present obstacles, the lack of capital, the want of machine shops, difficulty of obtaining engineers, and the scarcity of fuel, appear so formidable that no one as yet has the courage to face them.

The following year the report of the labor committee read:

Labor has been a subject of much anxiety with planters on the different islands. The planters had long foreseen that laborers would have to be brought from foreign countries; their anticipations were now matters of fact. Sugar plantations find it difficult to engage natives for any long term of time, a few only are willing to engage for more than three to six months. Importation is the only reliable source for permanent labor. Importation has commenced, and thus far promises to be satisfactory. Since our last meeting, the ship Thetis has arrived from Amoy, China, with about two hundred coolies, which were distributed among the planters, as by contract entered into with the master, John Cass, before sailing from Honolulu.

They have proved thus far diligent, but not swift; obedient, but require looking after. Planters have different views as to the relative value as laborers between coolies and natives. Some think four coolies equal to five natives, in amount of labor; others reverse the matter by placing three natives against four coolies. On the plantation of H. A. Pierce & Co., there was some apparent jealousy by the natives when the coolies first arrived among them. At Koloa, some little skirmishing at first, but it soon subsided; peace and harmony soon produced the kindest feelings. The coolies are far more nice in doing their labor, of which they feel a pride over the natives, calling them "Wahine! Wahine!" (Women! Women!). On Dr. Wood's plantation coolies are considered far superior laborers to the natives, they perform more work, and do it better and handsomer.

The wages of the cooley is, by contract, three dollars a month, then the passage from Amoy, advance wages, and outfit, amount to nearly four dollars, which added to the wages make nearly seven dollars, this sum includes the board on the plantation. Natives have six dollars a month and find themselves.

Further developments in attempting to establish the industry are taken from Thrum:

Up to 1857 we notice the struggle of this industry to be one of hardships and disappointments. The Lihue estate, after an expense of \$7,000 in digging a canal to enable

them to convey water for irrigating their fields, had now but the prospects of a change in the result of their labors which for five years had yielded nothing but disappointed hopes.

At this time the number of plantings had dwindled down to five, consisting of the Koloa and Lihue on Kauai, which were run by water (Lihue having steam to use as an auxiliary); East Maui and Brewer plantations on Maui worked by mule power, and one on Hawaii near Hilo, by Chinese (Aiko), run by water power.

These were followed during 1857 by two new ones in or near Hilo, one by Samsing and Company, and the other by Utai and Company, Chinese merchants of Honolulu.

The next extension we find to be in the latter part of 1858, when the Makee and Haiku plantations of Maui and the Metcalf plantation of Hilo were laid out.

Our planters, ever on the watch for improvement, turned their attention, about 1858 or 1859, to steam as the motive power in sugar making, when the Haiku Plantation was established with steam for grinding, boiling, and finishing, and commenced its operations in the season of 1861-2. Another stride for improvement was in the introduction of vacuum pans for finishing, the first of which was put in operation at the Kaupakuea Plantation, in 1861, and the year following one was set up at Lahaina. The mode of sugar boiling on all the plantations, was, with these exceptions, by the open train, and while our large planters were seeking to improve their works by the addition of steam strike pans, vacuum, or wetzel pans, the number of small planters were increased by the advent of the sorghum pan, which allowed many to start operations on account of the small amount of capital required for commencement.

The number of plantations in operation at this time (1861) were twenty-two, of which nine used steam as the motive power in grinding, twelve were driven by water, and one by animal power.

About this same time an effort was made by a joint stock company towards the establishment of a sugar refinery in Honolulu, which commenced operations the following year, but after a struggle of six years or so it closed its doors, never having done more than manufacture sugar from the molasses from the plantations and drain the pockets of its stockholders.

We have now reached 1861, and I set out to tell you of agriculture in Hawaii before 1860.

I trust that from the quotations I have made from these old papers that I have given you a better understanding of what it meant to be "in on the ground floor."

## Exotic Trees in Hawaii

By H. L. LYON

*Colvillea racemosa:* This is a very showy-flowered, leguminous tree from the South African region, which some observers consider "a worthy rival of the Royal Poinciana," to which tree it is rather closely related.

There is but one species in the genus *Colvillea* and the natural geographical distribution of this species has never been determined. Some botanists have ventured the opinion that it is a native of East Africa, but, so far as we are able to determine, it has never been found in a wild state. It was discovered by the



Fig. 1. *Colvillea racemosa*. A young tree of characteristic form with heavy clusters of pendulous racemes at the ends of the topmost branches. Photo by E. L. Caum.

botanist, Bojer, in 1824, who described it from a single specimen which he found under cultivation by the natives on the west coast of Madagascar. Seed from this tree was planted in Mauritius and the resulting trees have flourished and supplied seed for the wide distribution of the tree throughout the tropics of the world.

The first trees of *Colvillea* to be grown in Hawaii were reared from seed obtained from Ceylon in 1918 by J. F. Rock. The seedlings were grown at the Experiment Station and distributed about Honolulu for planting in public places and in private gardens. A few of these trees have done remarkably well and it



Fig. 2. *Colvillea racemosa*. Portion of a raceme showing buds and open flowers. From a colored plate in Curtis' Botanical Magazine.

now looks as though we can consider *Colvillea* an established plant in the gardens of Hawaii. A specimen in J. W. Waldron's yard in Nuuanu Valley flowered in 1925 and was the first tree of its species to flower in Honolulu. This same tree flowered in 1926, as did also one tree in the Makiki District and two in Kaimuki. The tree illustrated in the accompanying photograph is growing in the Makiki District in Honolulu. This picture shows the growth and foliage characters of the tree and its habit of flowering. Its feathery leaves are bipinnate and closely resemble those of the poinciana, although a careful comparison shows them to be somewhat larger and coarser than the leaves of the better-known tree. Its flowers are produced in heavy clusters of pendulous racemes at the ends of the branches. Each raceme carries many closely set buds, the ones at the proximal

end opening first. The buds have a velvety surface and are bright orange red in color. The conspicuous feature of an open flower is its cluster of ten long, bright yellow stamens. The buds are really more striking than the open flowers, so the tree is at its best when the first flowers are about to open. The flowers do not last long after opening. Mr. Waldron's tree set and matured one pod in 1925, but none of the local trees set any pods in 1926.

*Colvillea* is certain to become a popular tree in Hawaii, not because it is more showy than our brilliant shower and flame trees, but because it flowers at a season when these trees are in heavy leaf and fruit. Judging by the few trees which have already flowered in Honolulu, *Colvillea* is going to flower with us in October and November. In Madagascar, it flowers in April and May, but since its habitat in Madagascar is about as far south of the equator as Hawaii is north of it, the flowering period comes in the same season of the year. MacMillan states that *Colvillea* flowers in Ceylon in September and is suited to the moist or moderately dry lowlands.

*Terminalia myriocarpa*: This is one of the most promising forest trees among our recent introductions. It is a native of India, where it is known under the names Jhalna, Hollock and Panisaj. The one and only lot of seed which we have secured to date was collected in Northeastern Assam by J. F. Rock. From this seed, we reared about one hundred seedlings, which were distributed among as many situations as possible. In all places where the behavior of the trees has been followed, they are doing remarkably well. The excellent showing made by a small group of these trees in the wet lands above Pepeekeo on Hawaii is particularly gratifying in view of the fact that the majority of the other species of trees tried out in this region have failed to make any growth at all. A few trees of the Jhalna planted out by the Wailuku Sugar Company in its Waikapu Arboretum, which is located in a very dry situation, are also flourishing, while many of the other trees under test in this Arboretum have succumbed under the frequent droughts.

We planted out eight seedlings of *Terminalia myriocarpa* in the Manoa Arboretum in May, 1922. They immediately assumed, and have since maintained, the lead among the trees of the plantings of that year. An idea of the habit of growth displayed by these young trees may be gained from the accompanying photographs. In general, they suggest rank-growing guava bushes with exceptionally large leaves. From the literature, we learn, however, that they soon assume the habit of an upright tree and eventually attain very large dimensions.

Troup, in his "Silviculture of Indian Trees," pp. 532-534, gives us a very good picture of the tree in the description quoted below:

A very large evergreen tree with pendulous branches. Bark greyish brown, rough, exfoliating in vertical flakes. Wood dark brown, hard, used for house building, canoes, cheap furniture, and other purposes. The tree attains very large dimensions. Mr. Jacob<sup>1</sup> records one tree in the Raidak valley over 30 feet in girth, and two trees close together in the Chirrany valley roughly 36 and 27 feet in girth. Babu, R. N. De,<sup>2</sup> records a tree 46 feet 4 inches in girth round buttresses in the Lakhimpur district, Assam.

<sup>1</sup> Report on the Forests of Bhutan, 1912.

<sup>2</sup> Ind. Forester, xliv (1918), p. 517.

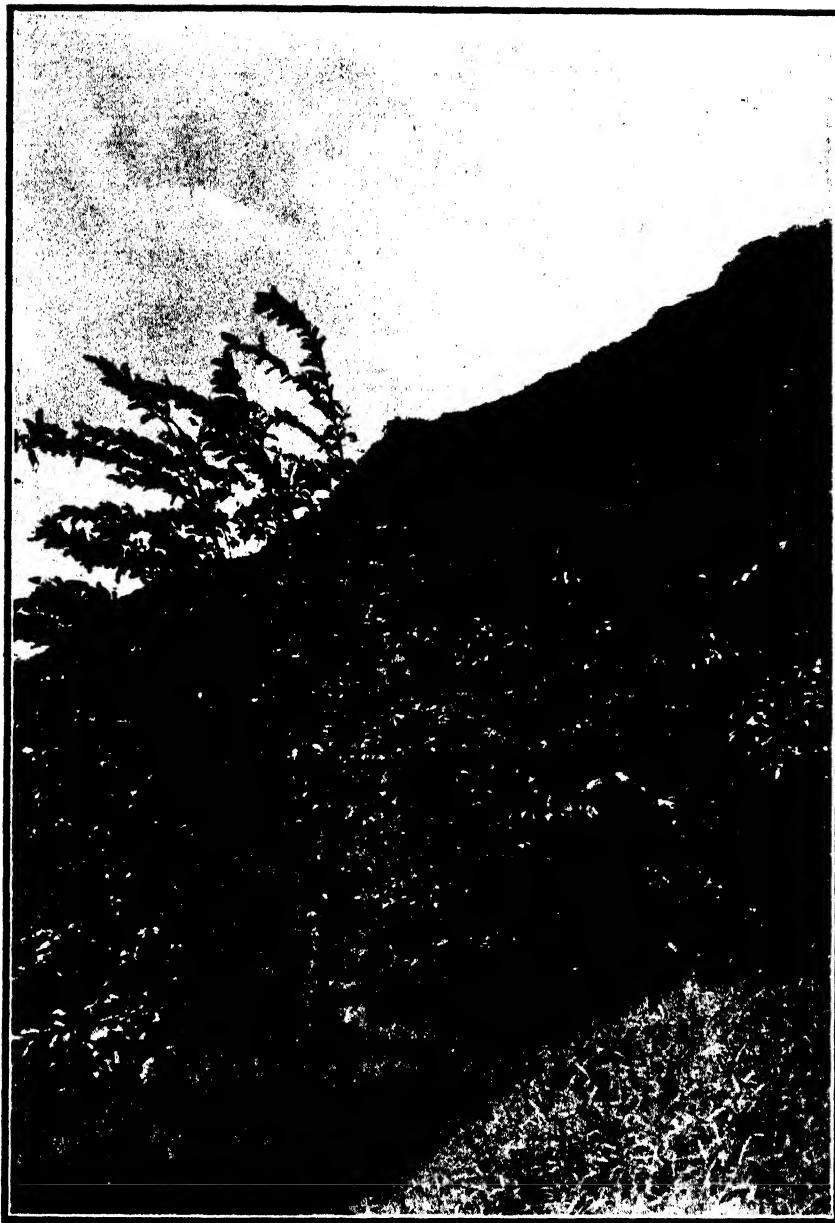


Fig. 3. *Terminalia myriocarpa*. A young tree, five and one-half years old from seed, growing in the Manoa Arboretum. Photo by E. L. Caum.

Eastern Himalaya from Nepal eastwards, in valleys and lower hills up to 5,000 feet, Assam, hills of Upper Burma. It is very plentiful in some localities, often coming up in gregarious patches on newly exposed ground, forming pure even-aged groups underneath which evergreen species appear. Mr. Jacob notes that it is very common in Bhutan up to 3,000 feet and is found up to 4,000 feet. Mr. Milroy<sup>3</sup> reports that in the Abor country it is the predominant tree on the lower hills, where trees of 12 and 14 feet girth are common, and still larger ones up to 18 and 20 feet are not scarce; he adds that although the trees are apt to be short in the bole and much branched a great quantity of clean timber could be extracted from them.

<sup>3</sup> Report on the Forest Resources of the Abor Country, 1912.



Fig. 4. *Terminalia myriocarpa*. Trunk of the tree shown in Fig. 3.  
Photo by E. L. Caum.

*Terminalia myriocarpa* is essentially a tree of moist situations and rich soil, and in Assam is often found associated with *Bischoffia javanica*. In its natural habitat the absolute maximum shade temperature varies from 90° to 102° F., the absolute minimum from 33° to 45° F., and the normal rainfall from 80 to 200 inches or possibly more.

The panicles of small pink flowers appear in October-November and the fruits ripen from March to June. The fruits are small and light, 0.1-0.15 in. long, light yellowish brown, with a pair of lateral membranous wings, the whole 0.4-0.5 in. in width. About 4,000 to 4,500 weigh 1 oz. The germinative power of the seed is fairly good, tests at Dehra Dun showing a fertility of 63 per cent, which for a small light seed is not unsatisfactory. Seed-year records show that the tree seeds well as a rule every year. The trees are a very handsome sight when covered with masses of pink blossom or yellow fruits.

In its early stages the seedling is minute, and is apt to be washed away by rain before it gains a footing. It develops rapidly, however, and attains a height of about 4-8 in. or more by the end of the first season. As in the case of *T. tomentosa* and *T. Arjuna*, the young plant has a tendency to produce long straggling branches in place of a definite leader, but in spite of this its height-growth after the first season is rapid. Sixteen plants grown at Dehra Dun had a height of 4 ft. 8 in. to 7 ft. 3 in. by the end of the second season, and 10 to 15 ft. by the end of the third season.

The tree bears a fair amount of shade and is exacting as regards moisture. It is not known to produce root-suckers.

The ideal conditions for successful reproduction are a loose porous soil free from weeds, in order to enable the small light fruit to reach the soil and the germinating seedling to establish itself quickly, and a fair amount of soil moisture. The light fruits tend to be washed into heaps and the minute seedlings are also liable to be washed away, considerable mortality resulting. The young seedlings are apt to dry up if exposed to the sun, and benefit by a certain amount of shade; they are also apt to die off in quantity on stiff water-logged soil, and good drainage appears to be necessary for their establishment. The young crop often tends to come up gregariously, where conditions are favorable, on newly exposed ground or fresh alluvium.

Direct sowings are unsuitable, as the small light fruits are liable to be washed away. Experiments at Dehra Dun showed that the best results are attained in fine porous sandy soil in boxes or in well-raised beds protected from sun and heavy rain; watering should be frequent but light. Germination ordinarily starts in two or three weeks and may continue for about three months. The plants transplant well during the first rainy season when 3 to 4 in. high.

## Rains Remove Twenty Times as Much Plant Food as Crops\*

Old mother earth's annual bathing bill costs the farmers of the United States more than \$200,000,000 every year. Rain water scouring the countryside, rushing down hillsides, gouging out gullies, and sweeping over gentle slopes of cultivated fields, carries away to the ocean many millions of tons of soil. With this rich topsoil goes 126,000,000,000 pounds of plant-food material—lost to the farmers of the country forever—twenty times the amount permanently removed by cropping.

But this is only a fraction of the damage wrought, says H. H. Bennett, soil scientist of the United States Department of Agriculture. The real scourge of erosion is that it takes not only the elements of plant food but soil—plant-food material and all—leaving in many instances infertile material very difficult to till. Erosion is constantly shaving off the topsoil of cultivated fields—the richest soil of the land. In one instance it was found that 7 inches of topsoil were removed by sheet erosion in 24 years from a gently sloping field of Putnam silt loam growing corn under ordinary cultivation in Missouri. Soil scientists agree that most of the worn-out lands of the world are in their present condition because much of

\* *The Journal of Heredity*, 17:430, 1926.

the surface has been washed away, and not because they have been worn out by cropping.

A single county in the Piedmont region was found by actual survey to contain 90,000 acres of land formerly productive but now permanently ruined by erosion. Another county in the Atlantic coastal plain has 60,000 acres of land, formerly cultivated, permanently destroyed by rainwash. Much of this could have been saved by timely terracing.

There is need at once for a nationwide awakening to the evils of erosion, says Mr. Bennett. There is immediate need also for fundamental soil data relating to erosion; demonstrations of the value of properly built terraces; and much national education about this menacing agency of land devastation.

[H. L. L.]

## Forest Destruction and Its Effects\*

The question of the action of forests on rainfall has been debated by foresters, agriculturists, engineers, and others for a long period, the discussion probably dating back to the time at which scientific forest conservancy was first introduced. In the tropical and subtropical parts of the world this is not, however, the point of primary importance. The vital factor for the community at large is the determination of how far the destruction of forests in catchment areas and on the sides of hills and mountains in the drier parts of a country affects, in the first place, the level of the water in the big rivers, a matter of extreme importance when the rivers are utilized for irrigation or power works; secondly, the decrease in the local water supplies and in local precipitations upon which the cultivator is dependent; and, thirdly, erosion and avalanches, and the destruction they cause in the fertile valleys beneath. Sudden floods may also cause enormous damage to railways, towns, and so forth. In India, which was the first part of the British Empire to give consideration to this aspect of the forest question, the matter has been the subject of discussion and reports through the whole of the past century, a statement which will perhaps come as a surprise to many in Great Britain.

The problem of affording protection to forests for the above causes alone is by no means new. In France and Germany special laws for the protection and extension of the forests and the protection of agricultural lands by means of the forest have long been in operation; and similar laws exist in the Italian States. So far back as 1475 the subject attracted the attention of the famous Venetian Council of X., by whom a law was passed on January 7 of that year, regulating in great detail the clearance of the forests on terra firma. The mountain forests especially were protected by judicious regulations, which were renewed from time to time down to the very year of the extinction of the old republics. Tuscany and the Pontifical Governments were equally provident.

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\* *Nature*, 119:37-39, 1927.

History has since shown that the wholesale destruction of forests in Spain, Italy, Sicily, Greece, and Macedonia has resulted in a great deterioration of climate over considerable tracts, due to loss of moisture, the sterilization of the soil, and excessive erosion.

Although now well known, the chief action of the forest may be stated briefly as follows: The great factor in mountainous and hilly country is the maintenance of tree growth on parts of the area. In the case of bare slopes the rain rushes rapidly down, causing erosion, only a fraction percolating into the soil, and is carried rapidly away, giving rise to spates and perhaps to serious floods, since the old channels of these streams or rivers are no longer able to carry the excess water of flood levels. A hot sun bursting out onto the slope after the rain quickly dries up the thin layer of moisture covering it. In the hotter parts of the globe subject to heavy rainstorms or monsoons the rushing water starts gullies which eventually become ravines, all surface soil is rapidly washed away, and in the course of years the hillside is eaten into, rubble and boulders being sent down to cover up valuable lands below. When the area is under trees, a portion of the rain, falling on the crowns, drips slowly down onto the layer of humus beneath and sinks into it. The larger portion, perhaps, falls direct onto the forest floor, where it is gradually absorbed in the soft covering which takes it up as a sponge. The water then percolates slowly downwards, filling up springs and underground reservoirs, and reaches the streams in a retarded manner. The flow in the latter is consequently more even and regulated, as also the amount of water which eventually reaches the rivers. The latter can therefore be more depended upon to maintain a normal level when it is required to utilize them for irrigation or power works. The roots of trees protect the surface by holding up the soil, and thus directly prevent denudation.

It is possible to give some concrete examples of the effects of the destruction of teak forests in India during the first half of last century, owing to the large demands for this timber from rapidly expanding markets.

The slopes on the west coast of the Bombay Presidency were once, even in the early days of British occupation, covered with magnificent, valuable, and extensive teak forests. These have long since been cut out, some disappearing for good. The denudation of the Deccan Highlands and the Eastern Ghats has resulted in excessive erosion and the gradual silting up of the rivers. When the Dutch, French, and English first built settlements on the Coromandel Coast, it was possible to take ships up the Godaveri and Kistna. The English port of Narasapur and the French one of Yunaon, both on the Godaveri, were once the chief ports on this coast. They can now be reached only at high tide by small native shallow-draught craft. Last year the present writer had arranged to go down the Godaveri from Sironcha, on the frontier of South Chanda (Central Provinces) and the Hyderabad State, to Rajamundri, as he wished to carry out investigations in connection with the effects of forest denudation on this river. It was early in March, the commencement of the hot weather season only. Inquiries elicited the fact that few rafts were now going down, owing to the extensive sandbanks already drying off in the river, and that even by dugout canoe, delays from stranding on sandbanks would be inevitable. Some hundred years ago this

great river was the chief artery or highroad into the interior. At Masulipatam, Dutch ships used to ride at anchor close up to the port, whereas at the present day even small native vessels have to anchor five miles out in the roads owing to the silting up. Between 1840 and 1850, Dr. Gibson, the first Conservator of Forests in Bombay, drew up a list of the rivers and creeks on the Malabar coast, where on arrival in those parts ships used to ride at anchor, all the creeks having silted up within the memory of men then alive.

Dr. Cleghorn, who afterwards became the first Conservator of Forests in Madras, directed attention to the destruction of tropical forests at the meeting of the British Association in Edinburgh in 1850. A committee was appointed to consider this matter. Dr. Cleghorn submitted its report, which was confined to India, the only country for which information was available, at the meeting of the Association at Ipswich the following year. The report summarized the position, as then known to the few in India who had given attention to the matter, pointing to the great and uncontrolled destruction which was taking place, both at the hands of timber merchants and owing to the careless habits of the native populations, who grazed their cattle at will in the forests and fired them every year in order to encourage the growth of new grass. The indigenous tribes in the hilly country also practiced unchecked shifting cultivation, a practice second only to the lumberer in the destruction of fine forests. Under this method, which was a common habit in Europe in olden times, a patch of good forest is felled and the material burnt in situ; coarse grains are then sown on the clearing. The cultivator then sits down and awaits the harvest. Two or three crops are taken off the area; the weeds then become too strong (as he never troubles to weed) and he moves on to a fresh area. The enormous destruction of virgin forest this practice entails, when practiced for centuries, has to be seen to be credited. Yet many of the tropical and subtropical forests in British Colonies and Dependencies are still subject to this the most pernicious and precarious form of so-called agriculture (as also to over-grazing and firing), the administrations responsible not having yet, apparently, understood the evils which attend it. The difficulties facing these governments in prohibiting the practice or controlling it were all experienced in India, in one form or another and overcome.

The encouragement given to the growth of tea and coffee and similar crops by British administrations in the Empire, whilst eminently praiseworthy if carried out on well-considered lines, has been productive of great harm in the past, and even the present day can scarcely be said to be free from anxiety on this score. In a report written in India in 1876 with reference to coffee planting, the following criticism is made:

The planters who come over from Ceylon are now giving a very high price for land, and the whole mischief may be effected in a very short time. It must not be supposed that coffee is at all a permanent cultivation; we have only to look at the Sampajee Ghat in Coorg, the Sispara Ghat in the Nilgris, and parts of the Annamalais to see at once that it is very often very little better than the shifting cultivation of the natives. It pays a coffee planter to take up a tract of primeval moist forest on our mountain slopes for a few years; he gets bumper crops the third, fourth and fifth years, but denudation of the soil and erosion goes on rapidly, and it does not pay him to keep it up many years.

Two other examples may be mentioned. In Ajmere-Merwara in Rajputana, all the waste and forest land was handed over to the people by government in 1850. The hills were rapidly denuded of timber and grazing was uncontrolled. The crops are irrigated from tanks (ponds) formed by building embankments across ravines. Some of these were very old. The rainfall is scanty and comes in heavy showers. The water, rushing down in torrents, quickly eroded the denuded hillsides, the tanks filled up with silt and debris or the embankments burst. In 1869, at the end of a two-year famine, the region was described as follows: "The cattle had perished, the people fled, large villages were entirely deserted and the country was almost depopulated." All this was due to the mistaken policy of giving to the people what they had clamored for, the uncontrolled use of the forest lands. An even more classic example is that of the well-known Hosiarpur Chos in the Punjab. These hills were formerly fairly well wooded. A rapid increase in population followed the advent of British administration in 1846. The consumption of forest produce augmented, the herds of grazing cattle multiplied excessively, and complete denudation ensued. This was followed by erosion, broad stretches of sand invading the plains beneath, with the result that the arable lands of 940 once prosperous villages were covered with sand, which laid waste upwards of 70,000 acres of fertile lands. In 1900 this formerly rich district was traversed by numerous broad, parallel, sandy belts cut out of the crop-bearing and fertile area.

In India these matters are now well understood, and the forest department, supported by the government, has control of the great forest areas. Proofs of the disadvantages and disasters following the uncontrolled wasteful utilization of the forests in mountainous and hilly country are not therefore wanting. It is known that the same processes are at work, and the same mistakes are being made, in our Colonies. It is the habit of British administrations to work in water-tight compartments. Probably the major portion of the difficulties being experienced in different parts of the Empire have been solved, or are approaching solution, in one or other of the provinces in India. They present no new features, as some appear to think, as the above-quoted examples go to prove. The chief difficulty is that action is delayed until almost irretrievable damage has been done and then the forester is asked to reafforest the areas so denuded. This entails an enormous expenditure, great skill, with success ever hanging in the balance.

Attention was directed to this subject at the meeting of the British Association in Edinburgh in 1920, when a paper dealing with the Indian forests was read. Resolutions of the same kind were also passed by the World's Forestry Congress held at Rome in May, 1926. As an outcome of last year's meeting of the British Association at Oxford, the chairman of the Forestry Sub-section, Lord Clinton, drew up for the council a brief statement dealing with the destruction of forests on hill slopes, with special reference to the tropical forests of the Empire. This memorandum has been submitted to the Secretary of State for the Colonies, by whom it is being communicated to the Colonies and Protectorates. It may be hoped, therefore, that the chief factors of destruction, namely, shifting cultiva-

tion, excessive grazing and the firing of forest lands, may receive that measure of considered control which the expert forestry services under the Colonial Office are fully capable of inaugurating if supported by the several administrations.

[H. L. L.]

## Safety First and Last in the Power Plant\*

By F. G. WHITNEY

*Superintendent, Hartford Electric Light Company, Hartford, Conn.*

When you stop to consider that each year about ninety thousand people die in this country as the result of accidents, and about two million more are injured, you can readily see how important it is to train and drill every man in your employ to be always on guard to avoid injury to himself and his fellow workmen.

I do not know what proportion of the total number killed or injured every year work in power stations, but I do know from my own experience that a great many men are hurt in power plants every day. Most of these injuries are of a minor nature and if skilled first aid is given immediately, cause no further trouble.

Whether these injuries are great or small, most of them are avoidable. Unceasing vigilance and persistent training—these and these alone—will keep down the toll of accidents.

Men doing the same work day after day don't think, or take a chance, or are in a hurry to finish a certain job, when off goes a finger or leg, or out goes an eye. There is a hurried trip to the hospital and maybe in a few days the men will all chip in to buy flowers for poor Bill.

Modern power plants are very safe as far as the apparatus is concerned, and so are the older plants. Where safety appliances once were lacking, these have been installed so that the old plants are often quite as safe as the newer stations. The fact is that there are not many more safety devices that can be installed on machinery; machines of most types are now about as safe as they can be made. If any appreciable reduction is to be made in this annual toll of life and limb, it must be done by education. This education, to be complete, has got to start with the man in charge and go right down through the whole organization to the tool boy. Great stress should be laid on safety at the foremen's conferences, once a month at least, until they know that it's up to them to reduce the number of accidents to a minimum.

A safety committee composed of men from the various departments is a very good way to get the men interested. This committee should be changed every three months, so as to get all the men acquainted and familiar with safety. What one group of men doesn't see or think of, another group may. It is also

\* From *National Safety News* for February, 1927.

a good thing for the man in charge to talk with the various groups, and have outsiders who may be interested in this movement talk with them, pointing out what is being done in other places to avoid accidents.

Committee or no committee, the foremen must be the main stand-by; they are the ones who must be instructed and drilled to carry out the greater part of this work. They are with the men most of the time and have direct charge of the various jobs, so it is up to them to see that the men take no unnecessary risks in their work.

I rather think that accidents to the eyes are the most numerous. Men do not like to wear goggles, but they are about the best eye protectors we have. They do get hot and covered with dust, but it is much easier to wipe off the goggles than it is to go through life with a glass eye. The goggles should be worn when chipping, using the emery wheel or doing anything where there is the least possibility of getting anything in the eye that might injure it.

#### MAKE IT A HABIT

Boards or planks lying on the floor with nails sticking up through them caused thousands of men to lose a foot or a leg or maybe life itself. Make it a practice to pick up or pile all boards taken from boxes or concrete forms so that it will be impossible to step on them.

Broken or wobbly ladders are responsible for many broken legs and arms, as well as more serious accidents. When a ladder gets in this condition, throw it in the furnace, or destroy it in some manner.

Old material lying promiscuously around the plant is very often an excuse for calling in the family doctor. Old steel beams, boards, broken bricks and other junk may cause someone to have a sprained ankle or fractured shin, if nothing worse.

Twisted or warped planks used in staging are likely to dump someone in the sump. When used for higher scaffolding, they may result in a broken back or neck, and maybe several of them. Planks so twisted should never be used except for firewood.

#### UNGUARDED OPENINGS

Some of the most serious accidents have been caused by leaving temporary openings in the floor unguarded for just a few minutes; someone happens along and down through the hole he goes. If that hole had been guarded with a rope or wooden rail or covered with planks, the ambulance would not have been called. It is the rankest kind of carelessness to leave an opening unguarded, even for a minute.

Of course all permanent openings or stairways should be guarded with strong handrails. Sometimes these handrails get loose or broken and in that condition are worse than none. When John tries to rest by leaning against the rail, he goes to a place where he can have a permanent rest and no handrails are needed.

Flywheels, gears, belts and any moving machinery where a man can get caught should be protected in such a way that it is impossible to get into them. Hand-rails may do; where they are not sufficient make guards of heavy steel wire fencing.

Most elevators are equipped with safety gates, but not all. Those so equipped are all right when the gates work; when they don't they should receive attention before some one falls down the shaft. Those not having safety gates should have some automatic device for protecting the shaft when the elevator is not at that floor. The other automatic appliances on elevators get out of order from time to time.

Poor lighting is another cause of numerous and varied injuries, all the way from stubbing your toe and biting your tongue to falling down stairs and breaking your neck or somebody else's. There is almost no excuse for not having proper light; one serious accident will cost more than all the necessary lights would amount to in several years. Stairways and all openings should be especially well lighted, the lights so located that they cannot shine in one's eye when going down stairs.

#### EMERGENCY LIGHTS

Emergency lights should be provided and installed at such places as need general illumination, as well as at stairways and other dangerous places. These lights should be connected to a separate storage battery or the control-switch battery, and should be tested every day to make certain that the automatic emergency switch is working properly and that no lights are burned out. In addition to the emergency circuits just mentioned, oil lamps should be set at all necessary and important places and lighted every day before dark.

Fuses and all automatic electrical devices for opening circuits should be inclosed or protected in such a way that when they blow or open, there will be no possibility of anyone getting burned. All wiring should be protected in the same way; many a man has taken a ride in the hurry-up wagon because wires were run in a careless manner or the insulation was poor.

Traveling cranes, like all other machines, have to be looked after. They need oiling or greasing; the cables or chains should have frequent attention, and occasionally a new part is needed. A good safe ladder is required to reach most cranes, and should be provided; the practice of walking along the crane track to go to or from the crane should not be allowed.

No man should be allowed on a crane unless he is used to working in high places and has good eyesight. Once in a while an operator gets rambunctious and thinks he is driving his flivver along some speedway, until he strikes the end of the building, maybe wrecking the crane as well as himself or someone else. Overloading cranes is bad practice, and generally unnecessary; you know the capacity of the crane and the load to be lifted. If it is too heavy, don't take a chance unless it is absolutely necessary. At least make certain that no one gets under the crane while it is overloaded.

Rigging of all kinds should be kept in good condition. When a rope is stranded, don't use it. If necessary to use it, cut out the stranded part and have a new splice made. The sheaves in blocks need oiling to keep them safe as well as easy to use. When moving heavy pieces on rollers, see that no one gets his foot under the rollers; it may slow up the job and incidentally smash the foot.

Chain falls may get you into trouble, if they are not kept in the pink of condition. When they get strained, they should be sent to the shop for overhauling before they are used again.

Badly worn tools are dangerous things to have around. Monkey wrenches, Stillson wrenches and open-end wrenches that are strained and sprung should be sent to the junk pile; they have a bad habit of slipping when in a tight place and may let Jim take a header to the basement floor, or hit Tony a crack in the jaw, making him swallow a few teeth, if nothing more. Cold chisels that are tempered too hard or whose heads are all flattened out, may snap off and fly into Bill's eye, doing more harm than he can repair in a month, or several of them. Worn hammers, with split handles, can also cause a lot of grief.

It is not necessary to use tools like these, the company doesn't want you to use them. You can rest assured that when tools like I have just described are used, and someone gets hurt, the powers that be will pin no medals on you for trying to economize.

Skylights or other glass in roofs of buildings must come in for regular inspection and regular maintenance to avoid the possibility of a painful and maybe serious accident. A one-inch wire screen under the skylight will catch any glass that may fall out.

Pipes are often run so low that it is impossible to pass under them without either stooping or hitting them. It's all right to stoop when there is plenty of time and the light is good, but when the lighting is poor or a man is in a hurry, he may not think to stoop. Where pipes are low enough to bump the head or low enough to be tripped over, they should be protected so that a man can not bump into them in the dark.

#### SAFETY DEVICES FOR GAGE GLASSES

Bursting gage glasses on boilers or receivers have given many a man nasty cuts and burns. There are several safety devices on the market to prevent such accidents, and it is a good investment to install them, if these gage glasses are low enough to fly and hit someone when they burst.

Safety valves have a bad habit of blowing when someone is in range of the business side of them; if a man does not happen to get burned he is lucky, but the chances are he will be badly scared. Lead the discharge side of the valve up through the roof, if possible; if not, lead it up high enough so it is over a man's head.

#### PROTECTION AGAINST DUST

When it is necessary for a man to work where it is very dusty—and there are a number of such places in power stations—he should always cover his face, or nose and mouth, with cheese cloth or some other protection, to keep the dust

from going into his lungs. The gas mask is better than the cloth, especially, if there is any possibility of gas. It is true that most men don't like to wear gas masks, but a little persuasion will help. After the first shock is over they will get used to them and there will be little further trouble. Gas masks should be worn when cleaning condensers, especially where there is much sewage in the condensing water.

I could write a book on the number of men who have been hurt, and some of them very seriously, as a result of horse play, but I'm not going to—not at this time. I'll wait and see if you habitual kidders and fellows that like to put up jobs on the other fellow cut out your nonsense before I write it. But at any rate, boys, cut it out; there is nothing in it. I went through the mill and I know.

Flammable materials such as oils, paints, varnish, gasoline, etc., should always be placed where there is no possibility of fire. The fire risk itself is bad enough, but there is the danger of an explosion, and of someone being injured. Gasoline and kerosene tanks should be buried underground. The other things mentioned should be kept in a fireproof room with smoking or lighted matches absolutely barred.

Another hazard is the empty oil barrel, which, like the empty gun, has sent many a man to the hospital. The barrel is empty—at any rate Joe thinks it is—but to make sure he lights a match so he can see the bottom of the barrel. It is needless to say that the barrel is empty long before Joe reaches the hospital. If it is necessary to look in, use an electric light, and ventilate the barrel before being too inquisitive. All empty barrels that have contained volatile material should be classed as dangerous.

There is not an accident described here that I have not seen, and some of them many times. A little vigilance on the part of the men or foremen would have prevented most, if not all of these accidents.

[W.M. E. S.]

## Zeolite Formation in Soils\*

By P. S. BURGESS AND W. T. McGEORGE

*A new line of attack for investigating soil fertility problems has developed following the discovery of the silicate compounds in soils known as zeolites. The leading investigators of soil problems declare these compounds to be fundamentally associated with most chemical and physical properties of soils. This line of investigation promises to throw considerable light upon the interactions which have occurred between the salts contained in irrigation water and the soils to which the water has been applied. Studies of the replaceable bases in the soils of infertile areas, in central Maui, have been carried on by Dr. F. E. Hance for the past eight months. Similar work will be undertaken shortly by W. T. McGeorge on certain Oahu soils.—G. R. S.*

\* A contribution from the Arizona Agricultural Experiment Station, Tucson, printed in *Science* 64:652-653, 1926.

The presence, in soils, of zeolites (basic hydrated aluminum silicates) possessing the property of base replacement, has been known and studied by chemists for a great many years. The source or origin of these chemical compounds is unknown, although most authorities, either by direct statement or by intimation, have given us the idea that, as they make up an important part of the clay fraction of soils, they are chiefly formed by the slow natural processes of decomposition, hydration and trituration under water, over long periods of time and are of great age.\*

During the researches being conducted in this laboratory upon the aluminates and silicates occurring in alkali soils, the following question arose: Having shown that black alkali soils contain sodium aluminate and sodium silicate in the soil solution, and having found that these two compounds will unite in the cold to form sodium zeolite, may we not consider such a union possible within the soil complex under natural conditions? The present paper constitutes a brief summary of detailed work which shows to our satisfaction that the zeolites now present in soils have not necessarily existed for untold ages but may be of very recent origin—in fact, may even now be in process of formation.

In preparing a synthetic zeolite by the above method, namely, from solutions of sodium aluminate and sodium silicate in the cold, the resulting colloid was found to possess extremely active base replacement properties. Also, upon adding small amounts of solutions of the above compounds to soils and allowing the latter to dry in the air at room temperatures we obtained a notable increase in their zeolitic content as indicated by quantitative base replacement studies. We have thus built up the zeolite content of a soil by adding the two compounds which we had previously shown would combine to form a zeolite, and which two compounds we have also shown to be present and to be often in process of formation within black alkali soils.

On mixing concentrated solutions of sodium aluminate and sodium silicate the resulting solution will almost instantly solidify to a gel. Dilute solutions, N/50 for example, showed no gel formation even on long standing. By titrating such a dilute solution with acid, however, it was found that zeolite formation occurred and, in dilute solution, is a function of reaction. Continuing this line of experimentation, we found that at strongly acid or strongly alkaline reactions a high concentration (due to high solubility) is essential to the formation of the colloidal zeolitic gel, while in dilute solutions the components combine within a definite pH range only. The maximum precipitate, or range of lowest solubility, is on the acid side of neutrality, pH 5 to 7. At pH 3.6 the zeolite was completely soluble. Our results to date indicate that it is far less soluble in alkaline than in acid solutions, although it has an appreciable solubility in both.

We thus obtained data in the above titrations showing that zeolites are completely soluble in dilute acids.† On titrating back with alkali, however, the colloid

\* Gedroiz claims that more recent "secondary absorbing complexes" in the form of "absorption compounds" may be formed by the union of particles of colloidal silicic acid carrying negative charges with those of colloidal aluminum hydroxide carrying positive charges, but that such "new formations" are extremely unstable, "decomposing easily into their constituent parts."

† This would confirm the results obtained by Kelley, Gedroiz and others who have shown that in attempts to use acids as a carrier of H ions in base replacement there is a disruption of the zeolite molecule.

was again formed and its typical base replacement property restored. To prove that the colloidal zeolite molecule had been broken down into its acidic constituents (silicic acid, aluminum chloride and sodium chloride) an acid solution of the zeolite was dialyzed through a paraloidion membrane, the dialyzed solution neutralized to a reaction of pH 6.0, and evaporated until a gel was again formed. This zeolite gel had reacquired its base replacement property.

After having formed the basic zeolite from its alkaline constituents, which we have shown to be present in black alkali soils, the acid zeolite was then synthesized from the acid constituents which are known to be present in acid soils. These are silicic acid and soluble aluminum and sodium\* salts (chlorides). The physical and chemical properties of all of these zeolites are being studied and their formulae determined.

The next step in our investigations was to extract the components of the zeolites from both alkaline and acid soils and cause them to recombine to again produce zeolites. Thus, a soil was leached with 3 per cent hydrochloric acid, the leachings evaporated upon the water bath to a gel, and this gel shown to possess the property of base replacement. A similar experiment using water or a solution of sodium hydroxide was carried out with a black alkali soil, with the same typical property of base replacement showing in the colloid obtained. In the latter case there may not be a destruction of the zeolite molecule during extraction, as the leachings from a black alkali soil will often contain sufficient soluble aluminates and silicates to recombine under proper reaction conditions to form the insoluble zeolite with replaceable base properties, without evaporation. As stated above, our work shows that the zeolite molecule is most stable under alkaline conditions. This is doubtless due to the excess OH ion present, which prevents hydrolysis. It is also very stable in the presence of an excess of the common metallic ion.

This work indicates that there is a great similarity between the soil zeolites as prepared either from acid or alkaline soils (acid extracts of the former and both water and alkaline extracts of the latter), and those artificially prepared on the one hand from aluminum chloride, silicic acid and sodium chloride, and on the other from an alkaline aluminate and silicate. In fact, we are inclined to consider them as practically identical.

The small amounts of soluble aluminum present in acid soils probably result from the solution, with accompanying decomposition, of previously formed zeolites which are slightly soluble at hydrogen ion concentrations below pH 5.0.

It is a widely known fact that black alkali (sodium carbonate) may be formed by the interaction between calcium carbonate and either sodium sulfate or sodium chloride. It may also be formed by the natural weathering of basaltic rocks. We are inclined to attribute the formation of zeolites in alkaline soils to the presence of black alkali formed as above (with attendant high pH), rather than consider black alkali as usually derived from sodium-zeolite hydrolysis. This latter explanation of black alkali formation appears to us to be putting the cart before the horse, for the major trend of chemical reactions in soils will be in the direction of synthesis of the least soluble product, which here, most assuredly, is the zeolite.

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\* Soluble potassium, calcium or magnesium salts may be used.

That sodium hydroxide may be formed by the hydrolysis of sodium zeolite, after the latter has been formed, is of course well known, but the importance of this reaction in black alkali formation in soils is open to question.

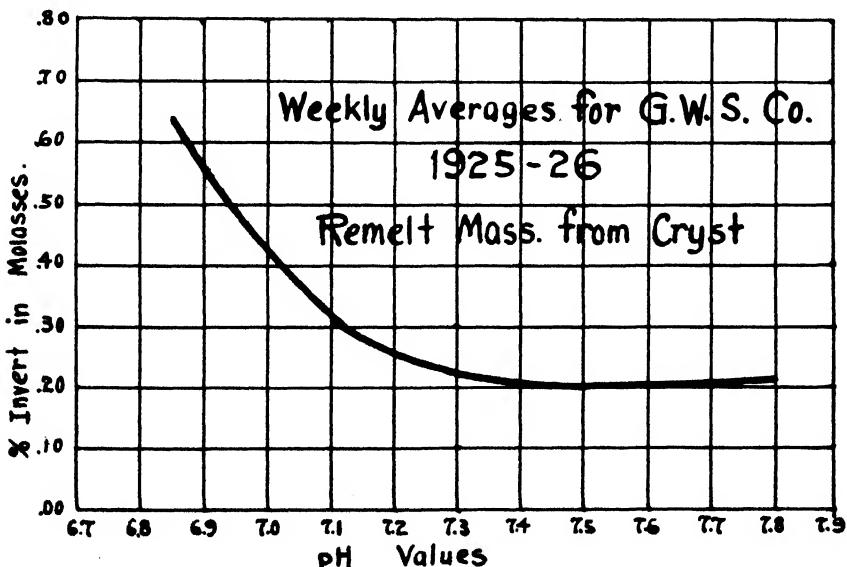
To recapitulate briefly, our work thus far indicates that the steps in zeolite formation in alkaline soils are somewhat as follows: Sodium carbonate is formed from the interaction between white alkali and calcium carbonate; the sodium carbonate hydrolyzes to give sodium hydroxide\*, which ionizes to produce a solution of high alkalinity (pH 10 to 11.5); sodium silicate and sodium aluminate are formed under these conditions from the more readily soluble aluminum silicate minerals; as the pH is lowered, due to washing out by rains or irrigation, or as the soil dries out, the sodium silicate and sodium aluminate combine to form sodium zeolite, which may remain as such or be converted into other zeolites, depending upon the salt concentrations within the soil solution.

A detailed account of this work soon will appear in the technical bulletin series of this experiment station.

## pH and Inversion in Beet Sugar Factories†

By J. H. ZISCH

It is planned eventually to put the factory control of the Great Western Sugar Company's plants on a pH basis, from blow-ups to sugar end, but at present this basis is applied chiefly to the last products. The author considers it probable that the lowest pH at which it is best to carry blow-up thick juice and both raw



\* In dilute solutions (N/20 or less), sodium carbonate is hydrolyzed to the extent of 65 per cent or more.

† In *Sugar Press*, Vol. 10 (1926), No. 6, pp. 16-17.

and white massecuite is exactly 7.0, but until more comprehensive data on the subject are available it may be advisable not to allow the pH to go below 7.2. Some work on the subject was done at several of the factories during the past campaign, and the accompanying curve shows the danger of inversion of sugar when the pH of massecuites is allowed to drop below 7.0 to 7.2. A pH of 6.8 to 6.9 results in the inversion of about three times as much sugar as is found with a pH of 7.2.

The phenomenal run during the last campaign at the Greeley factory (winner of the annual Great Western Sugar Company pennant race) is ascribed to the application of pH values in the control of the sugar end. Several weeks' averages showed alkalinites of from —.040 to —.070 for raw massecuites with practically no inversion, or at least nothing abnormal; this was equivalent to a pH value around 7.0.

In the curve, pH values as abscissae are plotted against per cent invert sugar in the molasses.

[W. L. McC.]

## Effect of Cane Tops on Sugar Recovery\*

By W. SCOTT

The following experiments illustrate the loss caused by the delivery to the mill of improperly topped canes:

Canes with green tops were selected from trucks in the factory yard; the tops (including green cabbage and white joints) were cut off at the base of the sheath. Canes and tops were ground in a laboratory cane mill and analyzed separately. The analysis of the whole cane, as given below, was calculated from these separate analyses (average of three tests):

	Tops only	Topped canes	Whole canes
Sucrose per cent.....	4.17	12.71	11.65
Juice—Brix .....	12.23	18.20	17.50
Sucrose .....	5.43	15.38	14.39
Purity .....	44.39	84.50	82.22
Weight per cent.....	11.84	88.16	100.00

A lower sucrose extraction was obtained from the tops than from the remaining portion of the cane. Allowing for this, but otherwise using figures representing normal factory conditions, it was found that the tonnage of cane required to produce a ton of sugar worked out as follows:

Canes free from tops, 8.72 tons.

Canes with tops, 10.34 tons.

\* From *Trop. Agr.* 3:235, 1926.

The tops representing 11.84 per cent of the weight of the cane, were responsible for an increase of 18.42 per cent in the tonnage of cane required to produce a given quantity of sugar.

It is therefore evident that the tops, while producing no sugar, cause an appreciable loss of the available sugar contained in the richer portion of the cane.

[W. L. McC.]

## Action of Sugar on Cement\*

By A. SETON

Lime dissolves in an aqueous solution of sugar to form a saccharate which is very soluble in water. It is therefore obvious that the presence of sugar in the water used for mixing, or in the cement itself, is highly deleterious. In some experiments an ordinary cement was used which gave a final settling time of 8½ hours when tested in the usual manner with the standard Vicat needle. When a 7½ per cent solution of sugar was used instead of water the final set was under 45 minutes. Briquettes were made up for the tensile test with a 20 per cent solution, and some broke on placing in water after 24 hours in the air in the moulds in a damp atmosphere. Others survived immersion, but none for more than six days. A further series kept in the air cracked after exposure for eight weeks. Briquettes made with a 1¼ per cent solution lasted for some months, but all cracked eventually. The le Chatelier tests showed the tremendous expansion that a very small quantity of sugar will produce. The original cement had an expansion of 2.5 millimetres, which the use of a 1¼ per cent solution of sugar increased to 15.5 millimetres. The result of such an expansion in a reinforced concrete cantilever or pile can be imagined.

The experiments led to the following conclusions: (1) the setting time of an ordinary cement is greatly reduced by the presence of sugar; (2) the tensile strength is also reduced, and immersion in water accentuates the weakness; (3) the expansion shown by the le Chatelier test becomes too large to permit the use of cement.

The work as carried out had reference to new cement only, and further investigation is necessary to determine the effect of sugar on concrete that has set. It would appear that as the free lime has become hydrated and carbonated, and to some extent has combined with the silica available, there should be very little action.

[W. L. McC.]

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\* From *Chemical Age*, 15:326, 1926.

## The Carbonatation Process in Natal\*

BY W. A. CAMPBELL

I am dividing my paper into the four following heads:

- (1) The reason for name, and basic principles of the process.
- (2) Kiln work.
- (3) Juice treatment.
- (4) Results obtained and advantages.

### NAME, AND BASIC PRINCIPLES OF THE PROCESS

In cane juice clarification, lime is almost the universal clarifying agent, but for a thorough purification, a large excess must be used, and this excess has to be removed by a neutralizer.

Carbonic acid gas has been found to be the cheapest neutralizer of excessive quantities of lime, and the most economical way of making use of lime and carbonic acid gas is by burning limestone (lime carbonate) in a lime kiln where 100 lbs. of limestone produces 56 lbs. of quick lime and 44 lbs. of carbonic acid gas.

As its name implies the carbonatation process is essentially connected with the production and use of carbonic acid for juice treatment.

By burning the limestone in a lime kiln, we separate it into its two constituent parts, that is, quick lime and carbonic acid gas. In the carbonatation of juice, we reverse the destructive work of the kiln, and combine again the carbonic acid gas to the lime in the presence of juice.

It is this formation of new soft powdered limestone in a dirty cane juice which constitutes the basic principle of the process. In doing this we change a large excess of pure lime into carbonate of lime, and the French chemists have named the process "carbonatation," and this name has clung to it, although more correctly it ought to be "carbonation."

### KILN WORK

The kiln here is the standard Belgian type and burns 40 to 50 tons of limestone a day in a continuous operation. When lit, a few days previous to starting the mill, the fire is kept alive right through the crushing season.

It is fed with limestone broken to the size of a man's fist, and coke in the proportion of 9 per cent coke to the weight of limestone. The coke is added to promote heat and also to produce an excess of  $\text{CO}_2$  (carbonatation) gas.

A lift raises the stone and coke in wagon loads to the top of the kiln, and at regular intervals charges of the mixture are dropped in by special arrangement.

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\* From a paper by the Managing Director, Natal Estates, Ltd., delivered before the Third Annual Sugar Congress, South Africa.

At regular intervals also the burnt lime is drawn away at the bottom of the kiln, so that the limestone and coke mixture is practically in a continuous slow descending motion in the kiln, whilst it is getting burnt to quick lime and ashes.

The heat of the kiln is maintained by the burning of coke, and also by the strong draught of a powerful gas pump, which regulates the burning of the kiln, and at the same time sucks the gas and delivers it to the juice side of the sugar house.

The presence of a pump intensifying the heat of a kiln and controlling its output of gas creates new conditions which do not exist in the usual lime kiln where the burning of lime is the only aim.

In our case burning of lime and gas production are of equal importance, and has to synchronise with the juice production of the factory; on that account a carbonatation lime kiln demands technical ability, and a vigilant scientific control.

The burnt quick lime is slaked and diluted to a cream in a rotary drum, which is sieved to get rid of unburnt particles, or dirt, and after cooling is ready for the juice treatment.

The carbonic acid gas sucked from the top of the kiln is cooled and scrubbed before reaching the gas pump.

The lime kiln, lime slaking and lime storage is in a separate building from the rest of the factory, and together with the gas pump constitutes a department of vital importance to a carbonatation mill, as any defect there would eventually cause crushing operations to stop.

A well balanced kiln work, which means perfectly burnt lime, and a plentiful supply of gas, is conducive to safe, easy running on the juice side to such an extent that sugar men experienced in the sulphitation process with the vagaries of that craft called "juice tempering," no longer care for this old process, and quite paradoxically, and contrary to the outsider's general opinion, call the CO<sub>2</sub> process the simplest in existence.

#### JUICE TREATMENT

The first step in juice treatment is heating raw juice from the mills to a temperature of about 140° F. This temperature fulfills the best conditions for gassing, filtration and color of juice.

The hot juice is sent to the gassing tanks where "carbonatation" is conducted.

Our practice is to fully open the valve connecting the gas pump to the carbonation tank, so that all the gas from the kiln is being blown into the juice, whilst a continuous stream of lime cream runs in the juice, mixes with it, and is carbonated.

The lime cream flow is regulated so that nearly all the lime is neutralized and only a small percentage left as free lime. This is checked by means of specially prepared test paper which turns pink or white according to the amount of lime neutralized.

The reason for continually neutralizing the lime instead of letting the full quantity act on the juice, and then neutralizing (as is done in beet root practice), is

that with the new method the violent frothing common to juice full of free lime, is considerably diminished.

This frothing is particularly noticeable with Uba cane juice, and in our first trials we found that the viscosity of the Uba juice was such that for the first portion of gassing the juice would not absorb the gas, and because of this we pump the raw juice from the mill to the patent tower 30 feet high.

This juice meets the exhaust gas from the tanks and gives it a pregassing. It also acts as a save-all and foam breaker.

The addition of lime in the juice with its simultaneous carbonatation is continued until the operator judges that the juice is sufficiently treated for a quick filtration.

A sample of muddy juice taken from the tanks would then show in a test tube a quickly settling mud, with a clear yellow juice on top. The real test, however, is the speed of filtration when the juice is sent to the filter press.

An experienced carbonator adds a uniform quantity of lime in each tankful, and the safest method is to add a slight excess of lime in case juice from bad cane should have been treated. The average quantity of lime used for Uba juice is about 12 per cent by volume at 15° Baume.

Other countries would naturally think this excessive, but we find by practice that it is the safest figure we can use; although I have known juices for short periods to take only 8 per cent of cream.

The action of lime on hot juice is to neutralize the natural acidity of the juice, kill the germs, and coagulate and bind various impurities inimical to sugar extraction, and this action is further helped by the formation of carbonate of lime in the juice. Added in large excesses to the viscous Uba juice, it really changes for the better the physical qualities of the refractory juice, especially by acting on the gummy substances which in other processes slime the presses, retard the boiling, and diminish the extraction of crystals.

The juice treated with the proper quantity of almost neutralized lime can now be easily filtered in filter presses, where the mud is kept as a solid cake. The lime cake contains nearly all the carbonate of lime (limestone) from the kiln together with the impurities removed from the juice, and constitutes a very valuable fertilizer.

For every ton of sugar produced, one ton of this fertilizer is sent to the fields.

Due to its porous nature this cake is easily washed free of the sugar it contains, so that in spite of the heavier quantity of cake manufactured in the CO<sub>2</sub> process, the sugar losses in scum cake are smaller than those of any sulphitation mill. The cake is washed until it contains but one-half per cent of sugar by weight of the cake. The defecation process gave us 8 to 11 per cent by weight.

The clear filtered juice containing a small amount of free lime in solution is sent to a second series of carbonatation tanks where the final neutralization is carried out.

Carbonatation, carried out in two stages, that is, double carbonatation, is safer than the single process, as it allows of rectification of mistakes at the first stage.

Whereas the first carbonatation takes an average of 10 minutes, the second one is carried out in about 1 minute, but demands a finer adjustment, as it is the final gassing.

The second CO<sub>2</sub> juice after neutralization is heated to 165° F. and sent to another series of filter presses where the small residue of lime carbonate in suspension is removed.

The clear filtered neutral juice is then slightly sulphured to a quantity equivalent to a tenth of that used in sulphitation mills when juice becomes slightly bleached, a favorable condition for white sugar. It is then heated to boiling point and filtered again.

From there it is concentrated and another filtration given, after which it is boiled to grain.

#### RESULTS OBTAINED AND ADVANTAGES

1. All juice from the mills reaches the evaporator in 30 minutes. Probably 4 or 5 hours were required with the former process.
2. The mills have an uninterrupted run.
3. Due to pure juice obtained, the capacity of our boiling house and centrifugal department has increased at least 30 per cent.
4. An increased recovery of sugar. Better quality of sugar.

#### COMPARATIVE FIGURES OF SULPHITATION AND CARBONATATION MILLS IN WHITE SUGAR MANUFACTURE

1. Rise in purity from raw juice to syrup: Sulphitation, .5 to 1.5. Carbonatation, 4 to 6.
2. Gallons of molasses per ton of cane: Sulphitation, 6 to 7. Carbonatation, 4 to 5.
3. Sugar lost in molasses per cent of the sugar in the juice: 13 per cent to 14 per cent sulphitation; 8 per cent to 11 per cent carbonatation.
4. Weight of scum cake per cent cane, 3.5 to 4 sulphitation; 10 carbonatation.
5. Loss of sugar in cake per cent sugar in the juice, 3.5 per cent sulphitation; 0.5 per cent carbonatation.
6. Recovery of pure sugar in bags, per cent of the sugar in the juice, 73 per cent to 77 per cent sulphitation; 83 per cent to 84 per cent carbonatation.

[W. L. McC.]

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## The Most Important Loss in the Manufacture of Sugar from the Java Canes\*

BY WILLIAM E. CROSS, PH.D.,  
*Director, Sugar Experiment Station, Tucuman, Argentina*

In the manufacture of sugar from the Java canes P. O. J. 36 and 213, there is a source of loss which does not figure in the factory reports, but which nevertheless produces very serious losses, affecting both the factory and the cane grower, and producing enormous differences in their annual balances, in some cases even converting gains into losses. We refer to the loss produced by not grinding freshly cut cane, owing to the deterioration which results between the cutting and the milling.

When other perishable products like milk, vegetables, etc., are concerned, the farmer never allows several days to pass before taking his products to market; but the cane grower, whose product is equally perishable, frequently allows himself the luxury of a considerable delay in delivering his cane to the factory, perhaps not realizing the great losses produced in this way.

This Experiment Station called attention to this peculiarity of the Java varieties so far back as 1914†, and since that time has frequently insisted on this matter, without having been able to convince more than a part of the cane growers and factory owners in Tucuman of the absolute necessity of grinding these canes within one or two days of cutting.

That some *ingenios* still grind a good part of their cane in a deteriorated condition, we know from our own observations, as well as from conversations with superintendents of factories, and from many factory reports. We know some factories, for example, whose annual reports indicate a high Brix in the normal juice, for instance 18 or 19 per cent, with a purity of little more than 70 per cent, this being an indication of an exaggerated case of having ground old deteriorated cane instead of fresh cane, and indicating also a loss of several tenths of 1 per cent in the yield of sugar per cent cane obtained in the factory, as well as several hundreds of dollars—lost by the growers who supplied the factory with the cane.

Seeing that the degree of deterioration which the cane suffers after cutting depends on climatic conditions, it is impossible to establish an exact relation between the number of days which pass between cutting and milling, and the damage which the cane suffers; but, taking the average weather conditions of the crop in this country, we may arrive at figures which are very significant. The data which we will proceed to give are based on results obtained in the experiments of this Station‡.

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\* Circular 16, Agricultural Experiment Station, Tucuman.

† Revista Industrial y Agricola de Tucuman, 1914, 5, 277-290.

‡ Idem, 1916, 7, 219-250.

### LOSSES FOR THE CANE GROWER

Immediately after cutting, the cane begins to suffer a loss in weight, for which reason even the grower who sells his cane without reference to its sugar content suffers a definite loss every day that passes between the cutting and the delivery of the cane to the mill. This loss results on an average between 1 and 2 per cent of the weight per day. This means to say that the grower, who is accustomed to deliver his cane during the crop some 5 days after cutting, loses on the average between 100 and 200 lbs. on each ton. Or in other words, the grower who produces 10,000 tons of cane does not deliver more than 9,500 or even 9,000 tons to the factory, which implies a loss of several thousand dollars a year.

It will be seen that this loss is of sufficient importance to warrant a serious effort to avoid it. It is true that by keeping the cut cane well covered with trash the loss can be limited to some extent, and in cases where the delivery of the cane has to be delayed for reasons beyond the control of the grower, this procedure should always be followed; seeing, however, that this method does not eliminate the loss, but simply reduces it, it can only be considered an emergency measure for occasional cases.

If the grower sells his cane on the sugar content basis, in delaying the delivery of the cut cane he not only suffers from the loss in weight, but also from the reduction in sugar content that the cane suffers, of which we will speak in the next paragraph.

### LOSSES FOR THE FACTORY OWNER

If the loss in weight which is produced by the drying-out of the cane were not accompanied by chemical changes in the juice itself, there might be a certain advantage to the factory in receiving from the grower cane that had been cut some days, as the growers and cane cutters would be paid for a less weight of richer cane. But, unfortunately, there occurs an alteration in the sucrose content of the cane, which takes place simultaneously with the loss in weight, if not, indeed, even more rapidly. As the cut cane begins to "invert," the sucrose becomes converted into uncrystallizable products. This inversion is due to an enzyme produced in the cane, principally after it is cut, which increases in proportion day by day, producing a correspondingly greater degree of inversion from one day to another. In this way the rate of the inversion process increases in a kind of arithmetical progression, the amount of sucrose lost on the 6th day, for example, being much greater than that inverted during the third day. For this reason, probably, during the first few hours after cutting (the number depending on the climatic conditions) the cane does not suffer any inversion at all. But the enzyme soon begins to form, and to produce the inversion for which it is responsible.

It may be said that under Tucuman conditions, cane which is left more than 48 hours after cutting incurs a very serious risk of loss of sucrose by inversion, and that after this interval the cane suffers, on the average, a daily loss of between 1 and 3 per cent of its purity, according to the weather conditions.

The loss produced by this inversion is much more serious than would appear at first sight. In the first place, not only have we a loss in sucrose, but the sugar

that remains in the juice is proportionately less available than it was. To explain this point we might take an example. A certain cane at the moment of cutting had the following composition (of the juice) :

	Per cent		Per cent
Brix . . . . .	14.6	Glucose . . . . .	9.6
Sucrose . . . . .	11.8	Purity . . . . .	80.8

Of this sucrose, 90.5 per cent was available. Three days later the cane had lost 6.3 per cent of its weight, and the analysis of its juice was as follows:

	Per cent		Per cent
Brix . . . . .	15.6	Glucose . . . . .	1.0
Sucrose . . . . .	11.9	Purity . . . . .	76.3

Taking into account the loss in weight, the net loss of sucrose was 0.65 per cent, and of the sucrose that remained in the juice only 87.7 per cent was available.

Besides the actual loss of sucrose produced by the inversion, and the lower availability of that left in the juice, the damage done to the cane is increased by the harmful effect of the substances produced by the deterioration, as the inversion of the sucrose is accompanied by other chemical changes in the juice. The substances referred to seriously affect the manufacturing processes, the juices of "inverted" cane being more difficult to clarify and filter, and the syrups more difficult to boil, than with freshly cut cane. More time is required for the several operations of the manufacturing process. For this reason the factory which works on the basis of cane cut some days suffers losses much greater than those indicated by the simple analysis of the cane, and also finds that its daily capacity is reduced and that its cost of production per pound of sugar is increased.

The cane grower who sells his cane to the factory for a percentage of the sugar which it yields suffers a double loss if he delivers cane cut some days: the loss in weight, and the loss produced by the inversion. That is to say, the weight of the cane received by the factory is less than it was when it was cut, and the yield of sugar it produces is less than it would have produced if it had been milled without delay after cutting.

#### HOW THESE LOSSES CAN BE PREVENTED

The losses produced by milling deteriorated cane are of such magnitude that even the most heroic measures are justified to prevent them. Some factories and growers have taken the necessary steps, but others have confined their efforts to trying to hurry up deliveries without modifying their organization, etc., in such a way as really to solve the problem. It is clear that the matter deserves the special attention of the managers of these factories, who ought to make radical changes in their methods of harvesting and delivering the cane in order to meet the case.

For example, in many parts the harvesting of the cane is done by men working individually, and paid by the weighed cartload. Before a cart can be loaded the man himself must cut enough to fill it, which takes him between two and three days. The greater part of this cane is thus more than 24 hours old when the cart is loaded, and some of it much older. If the cane is cut by gangs of workmen

on the other hand, the loading can proceed parallel with the cutting, in such a way that the cane is loaded within a very short time of being cut. It is our opinion that in all cases of cane taken to the mill in carts, it can be made to reach the factory within 24 hours of cutting.

When the cane has to be transported by rail, we admit that the problem of quick deliveries is a more difficult one, as it is true that in many cases serious delays are produced due to lack of wagons, or because the cane is moved slowly even after the wagons are loaded. But we think this is due in part to the fact that the railway authorities have not realized as yet the fact that the peculiarity of the Java cane to "invert" rapidly after cutting necessitates that it should be treated with the same preference as milk, vegetables, etc., the Java cane being in this sense very distinct from the old purple and striped varieties which were formerly planted here. It should be the function of the cane growers and factory owners and their unions and associations to educate the railway authorities and employees regarding this matter, in the hope that once they realize the perishable nature of these varieties of cane they will treat them accordingly, hastening their transport in every possible way.

As the transport of cane by rail implies a delay which is up to a certain point inevitable, it is especially important to be sure that this cane does not suffer any further delay in being loaded into the railway wagons, and later before being ground once it reaches the factory. If, as we have said, the cane taken to the factory in carts requires to be loaded the same day as cut, this is all the more necessary in the case of cane to be transported by rail. Nevertheless this is a point which is not always properly realized. We know of cases, for example, where the cane is loaded on to the railway wagons 4 or more days after cutting. We had to investigate a case in which the cane transported by rail to the factory always arrived in a very deteriorated condition. We were able to show that the rail transport required 3 days on the average, but that the cane was only loaded on the railroad wagons some 5 days after cutting. Thus with better organization regarding the deliveries of cane to the rail head, the loss through inversion suffered by this cane could have been reduced by much more than half. We wish to emphasize this point, as we have found that in some factories it is customary to lay the blame for the bad condition of the cane on the rail transport without taking the necessary steps to prevent the avoidable delays in delivery to the railway wagons.

Seeing that with the system of loading in vogue in this country, chain slings are used for handling the cane, delays are sometimes produced by the fact that the growers have not received promptly from the factory the chains they need for loading. It is in the interests of the factory itself to organize its work in such a way that delays for this reason will be reduced to the lowest possible limit.

Even though for lack of wagons, or other reason, fortuitous delays are occasionally produced, the inversion suffered by the cane can be reduced to a great extent by employing the measures indicated by this Experiment Station some ten years ago. At that time we showed that the cut cane placed in piles and carefully covered with trash suffers less than that exposed to the air, and that if this cane can be kept in a moistened condition, by throwing water over the piles of cane several times a day, the inversion can be reduced to a veritable minimum.

In some cases the cane which is several days in transport by rail might be drenched with water by a hose or other means at several points on the journey; the organization of this practice would cost very little in comparison with the benefits it would produce. And in the case of a breakdown in the factory, the cane should not be left in the fields, but should be accumulated in the factory yard, where the piles should be drenched with water two or three times a day at little expense.

In conclusion, we will repeat a recommendation which was also made by us several years ago. In our investigations, to which we have referred, we were able to show that the rate of deterioration after cutting varies very much with the variety of cane, some varieties suffering comparatively little in this respect, in contrast to the P. O. J. 36 and 213 which are among the canes that invert most rapidly. If therefore because of the distance of his plantations from the factory or for other reasons, a grower knows that his cane will always have to suffer a considerable delay between cutting and milling, he should not cultivate these rapidly inverting varieties, but rather those which we have shown to invert only slowly even after being cut many days; such, for example, as P. O. J. 2725, P. O. J. 228, D 1135, and the old purple and striped canes, the first mentioned of which we consider the best under ordinary conditions.

[W. L. McC.]

## Seedling Propagation and Selection in Java\*

*In a recent publication from the Experiment Station at Pasocrocan, Dr. J. P. Bannier, the botanist at that Station, describes in considerable detail the methods of crossing, seedling propagation and selection which are now being followed in Java. A review of the paper, which has been translated through the kindness of Mr. W. van H. Duker, is presented in the following pages.—A. J. M.*

### SELECTION OF PARENT VARIETIES FOR CROSSING

In addition to the varieties and combinations which have been found in the past to produce good seedlings, new varieties and new combinations are added each year to the crossing program. As far as possible all varieties available are tried out as parents; inferior canes possessing certain desirable qualities as well as the highly productive varieties are included. It has been found that crosses between two superior varieties often produce inferior offspring, and that desirable seedlings may be obtained from parents which are themselves inferior.

It is desirable to cross both good and poor varieties with a number of others to determine, so far as possible, the qualities which a given variety tends to transmit to its offspring.

\* From *De Rietveredeling aan het Suikerproefstation te Pasoeroean; Techniek, Rijching en Resultaten van 1893-1925. Archief voor de Suikerindustrie in Nederlandsch-Indië, Jaargang 1926, No. 19.*

## PREPARATIONS FOR THE CROSSING CAMPAIGNS

## A. Observations on Tasseling.

The tasseling season in Java usually lasts from the middle of March to the end of May.

The first move at the beginning of the crossing season is to determine which varieties may be expected to tassel.

The first sign of tasseling is the so-called "boenting" stage, in which each new leaf blade becomes shorter than its predecessor while its sheath becomes longer.

The second stage is marked by the appearance of the flag.

The third stage begins with the appearance of the tip of the tassel.

The fourth stage is marked by the opening of the first flowers, indicated by the extrusion of the stigmas and anthers.

The dates of appearance of these four stages are recorded each year. These records, if kept over a period of years, may be expected to supply information as to the influences exerted by outside circumstances on the time of tasseling of the different varieties.

The time of tasseling of a given variety may vary considerably in different years, depending upon time of planting, soil and rainfall.

In the crossing work at Pasoeroean this difficulty was met with: the breeding canes Glagah (*Saccharum spontaneum*), Kassoer\* and many Kassoer descendants tassel several weeks earlier than the best sugar producing varieties, so that it is difficult to cross the two groups. An attempt was made to hasten the flowering of the late varieties by earlier planting, but with poor success.

A solution of the difficulty was found by transferring the crossing work to the Malang Plateau. Here the tasseling periods of the two groups overlap more than at Pasoeroean. Here also certain varieties continue to produce tassels for six weeks to two months and many varieties tassel profusely which do not tassel at all at Pasoeroean.

This difference is thought to be due to the difference in climate. Pasoeroean is low, warm and dry, with a mean annual temperature of 79° F. and a rainfall of 52 inches. The crossing garden on the Malang Plateau has an altitude of 1200 feet, a mean annual temperature of 75° F., and a rainfall of 94 inches. Varieties such as Lahaina, Badila and Uba tassel heavily at Malang, and never at Pasoeroean†.

## B. Determination of Fertility of Flowers.

A second activity preliminary to the actual crossing is that of determining the quality of pollen of the different varieties.

The genus *Saccharum* is hermaphroditic, that is, the flowers normally produce both pollen and egg cells. There are, however, many varieties in which the pollen is nearly or entirely sterile, which may be used as females without castration. This is fortunate, since emasculation by hand is so laborious as to be impracticable.

\* This cane has recently been introduced for breeding purposes and is now growing on the Station grounds here at Honolulu. It has little sugar but is extremely hardy, and has been found in Java to be an excellent parent.

† Altitude appears to have the reverse effect in these Islands. The difference may be due to the fact that they are about 12° farther from the equator.

The quality of the pollen is determined as follows: Tassels of the varieties to be examined, are collected early in the morning before the beginning of pollen shedding, and are brought to the laboratory. Pollen shedding begins at about six and continues usually throughout the forenoon. The pollen is allowed to fall upon glazed blue or black paper. When a sufficient amount has been collected it is placed upon a glass slide and stained with iodine in potassium iodide. The well developed pollen grains are large and round; they contain starch and take a bluish stain, while abortive, shrivelled grains remain yellow. The percentage of functional grains is then estimated or determined by counting.

Those varieties in which a large proportion of the anthers shed their pollen normally, and in which a large percentage of the grains are well developed are used as male parents, while those producing little or no good pollen are used as female parents.

#### CROSSING METHODS

Four different methods of crossing are used: first, crossing in the open; second, bagging; third, "live" crossing, and fourth, the application of pollen by hand.

##### 1. *Crossing in the Open.*

In former years most of the crossing was done under bags, but at present the so-called "open" method is most widely used. Shortly before blooming the female stalk is tied to a bamboo pole. When the blooming begins a bamboo container filled with water is tied to the pole, and in it are placed two male tassels which are tied in such a way as to permit their pollen to fall directly upon the stigmas of the female tassel.

Since the cut tassels do not remain fresh more than 20 to 24 hours the male tassels must be changed daily. The best tassels for this purpose are those in which the blooming has proceeded a little more than half way down the tassel. In these a maximum number of flowers may be expected to open the next morning.

The time during which the male tassels may be changed is limited. The flowers open shortly before sunrise and a little later, between 6:00 and 7:00 a. m., pollen shedding begins. The shedding continues through the early part of the morning. During this period the air in a tasseling field is full of pollen grains and, inasmuch as the surrounding male tassels protect the female to a certain extent against foreign pollen, it would be undesirable to remove them as long as pollen shedding is in progress. It has usually ceased by 3:00 or 4:00 p. m. The male tassels are therefore changed in the morning before sunrise, or after 4:00 in the afternoon.

The duration in days of the blooming period of a female tassel, and therefore the number of times that the male tassel must be changed, ranges from four to ten—most frequently it is six or seven. It varies with the variety and with external conditions. In the cool moist climate of the Malang Plateau the blooming period is shorter than in the warm lowlands of Pasoeroean.

This method of crossing usually yields a good percentage of viable seed, although it varies, of course, with the fertility of each of the parents.

## 2. *Bagging.*

The percentage of viable seed obtained from this method is much smaller than from crosses in the open. It is therefore used only in scientific studies, where absolute certainty as to the parentage is essential.

The male tassels are placed in a bamboo container and are tied in position as in the "open" method. The pole, however, is in this case provided with a cross-piece from which is suspended a bag made of gauze, which completely encloses both male and female tassels. The male tassels must be changed daily, as before. The method is laborious, and, as stated, usually yields relatively little viable seed.

## 3. "*Live*" crossing.

In this method both the male and female tassels remain standing, and are bent toward each other and tied in such a position that the pollen of the male will fall on the stigmas of the female.

This method has the advantage that only one tassel is required for pollinating the female, but it has the disadvantage that to be used extensively it requires the planting of a special crossing plot. Even when this is done there is the chance that one of the two parents may fail to tassel. The method is only used when suitable male and female tassels happen to be near each other. No special plantings are made for the purpose.

## 4. *Hand Pollination.*

This method is regularly practiced at the end of the season when tassels are scarce. The pollen is collected from the male tassel on dark blue or black glazed paper, carried to the female tassel and applied by rubbing the latter gently over the glazed paper on which the pollen rests, or by means of a brush.

Of the four methods described the first is the prevalent one. The last three are used only in special cases.

## RIPENING OF THE SEED

As soon as the female tassel has finished blooming the last male tassels are removed and the female tassel is covered with a bag of mosquito netting, which serves as a protection against birds, against blowing away of the ripe fuzz, and against contamination by wind-blown fuzz from other tassels.

The length of the ripening season depends upon the variety and upon the locality. It is of longer duration at Malang than at Pasoeroean. The average, however, is about three to four weeks.

The separating of seed from the tassel and the drying of the flag are taken as indications of ripeness.

When ripe the tassel is cut and hung to dry for a few days in a place protected from rain, but exposed to light and air. When dry the individual seeds separate readily from the tassel. They may now be collected for sowing.

## SOWING

This is done in wooden trays about 20 inches square and 6 inches deep, having a few holes in the bottom for drainage. The trays are filled with fertile soil

consisting of a mixture of 1 part fine sifted soil (tarapan), 1 part sand and 1 part manure. Before mixing, the soil is exposed to the heat of the sun which tends to kill any weed seeds which may be present.

To prevent the fuzz from being blown away during the process of sowing the tray is placed under a cage of wire and cotton cloth provided with an opening through which the fuzz may be introduced. The fuzz is spread into a thin layer, well pressed down and moistened with a fine spray. It is finally covered with a very thin layer of soil.

The seed trays are exposed to the sun as much as possible, except between 11:00 a. m. and 3:00 p. m., when they are shaded to avoid burning. They are also protected during heavy rains by a light rainproof roof. During the first few days after sowing, or until germination begins, the trays are covered with muslin. They must be watered with a fine spray at least twice a day. Any weeds which may come up are eliminated at regular intervals.

#### GERMINATION

The fuzz germinates very quickly, usually two to three days after sowing. If after ten days no seedlings have appeared the seed tray may be discarded since no germination is likely to occur thereafter.

Some crosses yield much more fertile seed than others, consequently the number of seedlings per tray varies greatly. Some trays will yield only 5 or 10 seedlings while others contain thousands.

When the young plants are still very small they are often attacked by damping-off fungus which quickly destroys many of them. As soon as it is discovered the unharmed plants may be saved by removing them with a little clump of soil about an inch in diameter and planting them out in other seed trays. Spraying with pyoctanin solution is also sometimes successful in controlling damping-off.

#### TRANSPLANTING

When they are three to four weeks old the young seedlings may be transplanted into pots. Flower pots about five inches in diameter are used. They are filled with the same soil mixture as the seed trays; this mixture is as a rule rich enough so that no extra fertilization is required. A small hole is made in the loose soil with the finger or with a stick—it must be deep enough so that the roots can hang down freely. After transplanting the plants are well watered.

The work is done in a covered transplanting shed where the plants remain for about two days. By this time they have become sufficiently well established to withstand full sunlight, and they are placed in the open. They are watered at least twice a day, weeded regularly and the soil kept loose to facilitate the entrance of air. If the transplanting is carefully done the number of plants which die in the process is small.

Only 150 to 200 seedlings are saved from a single flat. The number which can be handled is limited by the available facilities and it is believed that the

chances of obtaining superior seedlings are greater when a relatively smaller number of seedlings is grown from each of a large number of combinations, than when a large number is derived from a single type of cross.

The young plants remain in the pots for about two months. At the end of this time they are about a foot high, and the root system is so well developed that it fills the pot; stooling is also well along.

### PLANTING IN THE FIELD

The seedling fields are laid out according to the Reynosa system of irrigation as universally practiced in Java. The seedlings are spaced about  $3\frac{1}{2}$  by 4 feet. The further treatment of the seedlings is the same as that for plantation cane, except that they are not so heavily fertilized. With the lighter fertilization the poor growers may be more quickly detected.

It is the practice to select as seedling fields those in which the soil is below the average. Seedlings with a poor root system may do well on good light soils and fail completely on heavy soils. It has been found that a greater percentage of selections made on poor heavy soils are likely to thrive under all kinds of circumstances than when the selection is made on good light soils.

### SELECTION

#### A. Time of Selection.

Formerly an attempt was made to exercise a certain amount of selection in the seedling trays. It is now believed, however, that this is a dangerous practice, since especially in crosses involving *Saccharum spontaneum* and Kassoer, rapid growth is often associated with sponginess and low rendement.

The present practice is to make the selections after tasseling is over, in May and June, when the seedlings are about a year old.

#### B. Manner of Selection.

The requirements which a seedling must meet if it is to survive the first selection are becoming more severe each year. It is the policy to retain only a very small percentage so that those retained may be the more intensively studied.

The following table shows the percentage of each year's sowings from 1911 to 1925, which were retained after the first selection:\*

1911.....	15.36%	1919.....	1.57%
1912.....	6.71	1920.....	1.06
1913.....	17.11	1921.....	.83
1914.....	3.28	1922.....	1.42
1915.....	.69	1923.....	.73
1916.....	4.25	1924.....	.60
1917.....	1.44	1925.....	.30
1918.....	1.20		

\* It is doubtful whether such severe elimination the first year can be safely practiced in these Islands, where the ability to carry over and to ratoon are important factors.

*C. Basis of Selection.*

The principal characteristics upon which selection is based are the following:

1. Length of Stalk.

The longest stalks are usually selected—those which are too short are immediately eliminated. To be retained a seedling which tassels must have a longer stalk than one which does not, since the weight per unit of length of the latter is usually greater than that of the former.

2. Diameter of Stalk.

This quality must be judged in connection with the number of stalks. Plants with a large number of thin stalks may yield as much as those with a smaller number of heavy stalks; there is, however, a minimum which cannot be exceeded. There is no maximum, but experience has shown that very thick stalks are as a rule not so desirable as one with stalks a little thinner. Very thick stalks few in number means too great a loss when a stalk is injured or broken. Besides, very large canes are often spongy or hollow, sometimes very brittle, with poor juices.

3. Conformation of Stalk.

Stalks which maintain their diameter well toward the top are to be desired. Stalks with straight and regular nodes are preferred to those with zigzag nodes.

4. Growth Habit.

A perfectly vertical habit of growth is preferred to a slightly inclined position since in the latter case the danger of lying down is great.\* Any seedling showing a tendency to recline, especially with limited fertilization, is rejected.

5. Internodes.

Long internodes are usually a very desirable quality. Excessive length may be objectionable, however, especially in thin canes. The nodes contribute more to the strength of the stalk than do the internodes. Prominent, bulging nodes are undesirable. Plants with many growth cracks are discarded.

6. Behavior of the Root Eyes on the Root Band.

In many seedlings the root eyes show a tendency to develop. Such seedlings are immediately discarded.

7. Conformation of the Eyes.

Some seedlings have protuberant eyes. Such eyes are liable to damage when seed is shipped, and this is therefore an undesirable quality.

8. Lalas.

Early or excessive lala-ing is undesirable.

9. Stooling Out.

This character cannot be as definitely determined in the seedling stool as in stools growing from seed pieces. Therefore seedlings with but two or three stalks need not necessarily be discarded. Excessive stooling may also be objectionable.

10. Position, Shape and Color of Leaves.

Since the growth of the plant depends largely on the quantity of chlorophyl-

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\* The climate of Java is such that any tendency toward recumbency is undesirable.

bearing tissue a wide leaf is better than a narrow one. Since sunlight which strikes the leaf perpendicularly causes greater assimilation than that which strikes at an angle, drooping or overhanging leaves have an advantage over those carried in a steep, erect position. Furthermore, an overhanging leaf closes in better and thus utilizes the light to better advantage. In general, dark green color is preferable to yellowish-green or light green.

#### 11. Self-stripping.

A prompt shedding of the old leaves is a desirable quality. Adhering leaf sheaths make harvesting difficult. Furthermore, they shelter pests and retain water, which encourages rotting and sprouting of the root eyes.

#### 12. Tasseling.

Excessive tasseling is an undesirable quality. There are some heavy tasseling varieties which suffer very little, but some plant food is inevitably extracted from the stem for the formation of the tassel. Other things being equal, non-tasseling seedlings are preferable to those which tassel. Tasseling can only be tolerated if the sponginess associated with it does not extend much below the tassel. Late tasseling is less objectionable than early tasseling.

#### 13. Uniformity in Size of Stalks.

Like stooling ability, this quality cannot be accurately judged in the seedling stool. However, seedlings showing great variation in size of stalk should not be kept.

All of the qualities mentioned above are observed on the standing stool. Seedlings which are satisfactory with respect to these qualities are given a number beginning each year with No. 1, prefixed by a letter reserved for that year. Thus 1924 = N, 1925 = O and 1926 = P. To illustrate, the 1284 plants selected in 1925 from the 1924 sowings received the numbers N 1 to N 1284.

After the field selection is finished and the plants sufficiently ripened (in July) the selected plants are dug up, roots and all, and brought to the selection room for the so-called mill selection. In the selection room the sticks are separated, and roots, dirt and leaf crown are removed and measured. A second selection on the basis of visible characters is made at this point. Comparisons between plants are easier to make here than in the field and usually quite a number are discarded.

After this selection the sticks are cut in two, and the tops, about one-third of the entire length, are saved to be used for seed if the juice and other internal characters are satisfactory.

Plants with dry, spongy or hollow pith are discarded. Perfectly solid sticks are most desirable.

All plants which remain after this selection are ground in a sample mill and the Brix and polarization determined. Growth conditions of the year in question are taken into consideration in determining the standard. In a year of high average rendements, for example, it is better to place the standard higher. The basis of selection therefore varies more or less, but at Pasoeroean, a Brix of 18 with a polariscope reading of 65 (sucrose 15.8, purity 87.8) is considered the

lower limit. Anything below this is discarded. The juice analyses, however, are always judged in connection with the habit of growth and other characters and many seedlings with good juices must be condemned. While not an absolute rule it frequently happens that the best looking seedlings have the poorest juices.

The top seed pieces of the plants which have survived the final selection are now planted in two or three rows. The number of seed pieces is, of course, limited, and the quality is sometimes poor on account of tasseling, so that it is often difficult to obtain a good stand. It may be necessary to resort to very wide spacing. These things must be taken into consideration in the second year's selection.

A few seed pieces of each of the very best plants are planted in a suitable place for spreading. These very best selections, seldom more than five in a family, are called "maximalists." As soon as the shoots of these plants are large enough to form roots of their own, usually in about  $2\frac{1}{2}$  months, they are removed and planted elsewhere—when these in turn have produced shoots large enough for replanting, the process, which is called "seblangen," is repeated. If a variety "seblangs" well the method permits of very rapid spreading. The ability to "seblang" has also been found to be a very good criterion of the vigor of growth and the root forming power of a seedling.

#### SECOND SELECTION YEAR

Selection in the second year is less difficult because 10 to 20 plants of each variety are now available. It is easier to determine whether a given quality occurs generally or whether it is sporadic. The stooling and tasseling characteristics can also be much more accurately determined the second year.

Notes are taken throughout the second year. Two or three months after planting the germination and stooling ability are recorded. A short time previous to tasseling, in February, further notes are taken of the habit of growth and the character of the top. The third and last examination of growth habit is made after the tasseling season in May, and a further selection is made, the elimination being based on the same characters as in the first year. At this time ten average stalks of each variety are labeled, an analysis of the juice of five of them made immediately, and of the other five in July, to give information as to the earliness or lateness of ripening. At this time the external and internal qualities of the sticks are again examined. The number retained after the second year seldom exceeds 25 per cent of those selected the first year. Juice analyses are made on all seedlings before elimination, however, to obtain information as to the relation to each other of the analyses for the two years.

The varieties retained after the second selection are now planted in a larger plot of 2 to 10 rows. In recent years the rows have been divided into halves, one of which is given a light and the other a heavy fertilization, in the hope that in this way some information might be obtained as to how the seedling reacts to favorable and unfavorable conditions. Thus far, however, the results have not been very definite.

If at the end of the second year a seedling should appear so superior as to give promise of outclassing the existing varieties, as much seed is planted as possible in order to supply those plantations who wish to have it. In this way the extension of new varieties proceeds very rapidly. Thus of P. O. J. 2878 there was in 1922 one mature plant; in 1925, 3062 acres; and in 1926, 43,750 acres.

### THIRD SELECTION YEAR

The selection in the third year is carried on in the same manner as in the second year but on a still more rigid basis. Seedlings surviving this selection are given P. O. J. numbers and are sent to plantations for field trials. The suitability of a seedling to a given soil type and its value as compared with the variety already being grown can only be determined by field trials in the area in question. The results of many years, however, have shown that the relative value in the selection plots checks with the relative value in field practice. The best seedling of a certain family in the selection plot is usually best also in field practice.

The P. O. J. series includes all seedlings grown at the Experiment Station, seed of which has been sent to plantations.

### AIM AND POLICY OF THE CANE IMPROVEMENT PROGRAM AT PASOEROEAN

The incentive to cane improvement may be traced back to the failure some fifty years ago of Black Cheribon\*, the standard variety, which began at that time to display pronounced susceptibility to the sereh disease. A search was therefore begun for varieties resistant to sereh which would yield as well as Black Cheribon. The different varieties of the Malay Archipelago were tried out first but they were either too low in yield or not sufficiently resistant. As soon as the possibility of sexual propagation of sugar cane was established this method was at once adopted with the object of finding a variety which might replace Black Cheribon. The history of the first attempts to obtain and germinate cane seed has already been related by Kobus† and Wilbrink and Ledeboer‡.

The aim throughout has been to obtain varieties which give a reasonable yield and which at the same time are resistant to sereh and yellow stripe. The first attempts in this direction met with little success, but it seems that in recent years this goal has been reached.

### THE POLICY OF CANE IMPROVEMENT FROM 1893 UP TO THE PRESENT TIME

The first seedlings were produced in 1893. At that time field crosses were employed. P. O. J. 100 was obtained among these first seedlings. It was a

\* Louisiana Purple.

† J. D. Kobus. Historisch overzicht van het zaaien van suikerriet. Archief, 1893, pp. 14-29.

‡ G. Wilbrink en F. Ledeboer. De geslachtelijke voortplanting bij het suikerriet. Archief, 1911, I, p. 367.

seedling of Bandjarmasin hitam (Rose Bamboo) crossed with Loethers. The work was under the direction of Wakker, at that time director of the Experiment Station.

In 1894 no new seedlings were grown. In 1895 and 1896, seedlings were again obtained mainly from field crosses. These two years did not yield any valuable varieties. Indeed, it would have been an unusual coincidence if anything especially good had resulted from the methods employed. In a crossing plot where many varieties are brought together and allowed to cross at random, the chance is small that pollen from the best male parent should happen to fertilize the best female parent.

To obtain a variety like P. O. J. 100 from this method is a very unusual occurrence.

#### THE CHUNNEE NOBILIZATION

In 1897, Kobus introduced a new method of attack. He obtained from British India, 18 different varieties which were temporarily placed in quarantine at Banka. In 1896, the best of these, Chunnee and Ruckree, were brought to Pasoeroean. These varieties have very thin sticks. However, they are extremely hard, produce fairly large stools and have a good rendement. They belong to the type designated by Jeswiet as *Saccharum barberi*.

In 1897, Kobus began crossing Chunnee with the large sticked noble canes. The process of crossing the thin sticked varieties with the large sticked noble canes will be referred to hereafter as "nobilization." Chunnee produces pollen, therefore it must be used as the male parent. Striped Preanger (Striped Mexican) was used as the female parent in that year.

In 1898 and 1899, Chunnee was crossed with Black Cheribon (Louisiana Purple). In later years other varieties were crossed with Chunnee, but up to 1912 the Chunnee-Black Cheribon crosses were the most numerous. A few crosses wherein Chunnee did not participate were made, but on the whole the period from 1897 to 1910 may be designated as a period of Chunnee nobilization.

During this period not only was Chunnee crossed with noble canes, but the descendants of these crosses were again crossed with the noble canes. The resulting seedlings were designated as "derived" or "twice nobilized" Chunnees.

Among the seedlings produced as a result of crosses between Chunnee and the noble canes are P. O. J. 36, 213 and 979. The principal properties of these and other Chunnee descendants are medium thickness, medium rendement, a tendency towards hollowness of the pith, resistance to sereh, strong root system, and therefore resistance to unfavorable conditions, high susceptibility to yellow stripe and a tendency to lie down. While they are able to compete fairly well on very bad soils none of them was outstandingly superior and they were never extensively planted.

In the years following 1905 attempts were made to obtain superior varieties by crossing together the best of the Chunnee hybrids. A number of seedlings which showed distinct improvements over the first generation of Chunnee descend-

ants were obtained in this way. They retained, however, their susceptibility to yellow stripe and none of them became very important as commercial varieties.

Thus, the Chunnee nobilization program yielded no very important results. Since 1914 Chunnee has entered less and less into the crossing program and at the present time it is no longer used in crossing work. Chunnee descendants, however, are occasionally used in combination with Kassoer and with Kassoer descendants.

#### IMPROVEMENT WORK WITH THE NOBLE VARIETIES

After the abandonment of the Chunnee nobilization program in 1912 and before the Kassoer nobilization program was begun, special attention was paid for several years to crosses among the noble canes themselves. Several varieties with good growth were obtained, especially from crosses between Fiji and Green German New Guinea. In general, however, those varieties having a good rendement were too susceptible to sereh and to yellow stripe to be of use. In recent years crosses between the noble canes have been conducted mainly with the object of studying the inheritance of their properties rather than with the hope of obtaining commercially important canes.

#### THE KASSOER NOBILIZATION CAMPAIGN

Kassoer was used in crosses with the noble canes as early as 1893 and especially in 1902, 1907, 1908 and 1909. However, the offspring of these crosses were not desirable as commercial canes because of their low rendements.

After the discovery that Kassoer was in reality a hybrid between one of the noble canes and a wild cane, Glagah\* (*Saccharum spontaneum*), it was realized that the first generation of Kassoer hybrids was still too closely related to their Glagah grandparent, which produces no sugar, to give a good rendement. However, when these twice nobilized Glagahs were again crossed with the noble canes the rendement of the offspring was considerably improved. Furthermore, they usually retained their resistance to sereh, along with a strong root system and a vigorous growth. At the present time most of the work at Paseroeane is conducted with thrice nobilized Glagah descendants. P. O. J. 2364†, which results from a cross between P. O. J. 100 and Kassoer, proved to be one of the best of the twice nobilized Glagahs. It has a very good growth habit, long straight joints, fairly large sticks, a strong root system and great vigor. The rendement is also very good as compared to that of other varieties of the same parentage. The fact that it transmits its good qualities to its offspring makes it especially valuable for crossing work. In fact, it has proved to be the best of the first generation of Kassoer hybrids for breeding purposes. It has been crossed with a

\* Glagah (*Saccharum spontaneum*) is a wild cane with little sugar and thin sticks, but quite resistant to disease.

† This variety is now in quarantine in Honolulu.

number of male parents. Thus far, crosses with E. K. 28\* have given the best results. The seedlings resulting from such crosses are characterized by vigorous growth, strong root system and partial or complete resistance to the principal cane diseases. They also have a fair rendement.

The thrice nobilized Glagahs have again been crossed with the noble canes. This fourth nobilization has yielded seedlings with better rendement than those of the third nobilization, but the resistance to diseases is somewhat less. In addition to noble canes with a high rendement it has been found desirable to use for the fourth nobilization noble canes which are as highly disease-resistant as possible, even though their rendement may be somewhat inferior.

#### NOBILIZATION OF *SACCHARUM SINENSE*

For several years a number of crosses were made with different varieties belonging to the species *Saccharum sinense* which includes Tek-cha, Puri, Uba, Swinga, Kavangire\* (Porto Rico Uba) and Cayana\*. The yield of these varieties is rather low but they have a fairly good rendement, a strong root system and resistance to sereh. The resistance to yellow stripe varies in different varieties, but is certainly less pronounced than was formerly believed. Many of these varieties transmit their undesirable qualities strongly to their descendants. Kavangerie has proved to be the most desirable for crossing purposes. In general, the nobilization of *Saccharum sinense* has not yielded important results.

#### THE INHERITANCE OF CHARACTERS

Because of the complex hybridity of sugar cane very little is known concerning the nature of the inheritance of specific qualities.

A mistaken conception which one sometimes encounters is the following: If one of the grandparents of a variety is Glagah and the other three grandparents are noble canes it is assumed that the variety is one-fourth Glagah and three-fourths noble. This, however, is incorrect. Due to the fact that the formation of egg cells and pollen grains the characters received from the two parents are distributed entirely at random, it may happen that such a variety may receive either much more or much less than one-fourth of its inheritance from the Glagah grandparent.

The offspring of all varieties is variable. It has been observed, however, that on the whole one variety tends to transmit certain qualities, another variety other qualities.

From the observations of many years, it is possible to draw certain conclusions as to the qualities which some of the better known varieties are likely to transmit when used in crosses. A few of the varieties and the qualities which they tend to transmit are listed below:

P. O. J. 2364\*. An exceptionally large number of crosses have been made with this variety during the last ten years. It transmits almost all of its good

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\* This variety is now in quarantine in Honolulu.

characters to its offspring. Its fuzz usually gives a low percentage of germination as compared with other varieties. The characters which it transmits to its offspring are the following: medium diameter, good length, strong root system and good rendement. Weaknesses of P. O. J. 2364 offspring are a strong tendency to tassel and sometimes sponginess. These characters must be strongly selected against. As male parents in combination with this variety as the female E. K. 28\* and S. W. 111 have up to the present proven best.

P. O. J. 2725\*. This variety produces seedlings freely, but they are of mediocre quality. Their principal weaknesses are coarseness, heavy tasseling, medium to poor rendement, prominent eyes and lala-ing.

D. I. 52\*. This variety usually produces but little fertile pollen and it has not given especially good results as a female parent. In recent years it has been found to give pollen fairly freely on the Malang Plateau, and while the results of crosses when it is used as a male are still scanty, it has been observed that the good rendement of D. I. 52 has been transmitted to various of its offspring, and that their growth habit is also fairly good.

E. K. 28\*. Of the male parents which have been extensively used, E. K. 28 is one of the best. The fertility of the pollen is often rather poor, especially in the lowlands. It transmits its good growth habit to its offspring, which also usually have a good rendement. One of the weaknesses of E. K. 28 is its heavy tasseling, which it transmits to many of its offspring. It usually transmits also its quality of late ripening.

S. W. 3\*. This variety is well suited for crossing with varieties having large sticks, because its small sticks are transmitted to many of its offspring. The stalks of its offspring are often variable in size and are sometimes inclined to be soft, although their growth habit is fairly good, their length satisfactory, and their rendement fair.

Bandjarmasin hitam (Rose Bamboo). This variety rarely tassels at Pasoeroean and the fertility of its pollen is poor. At Malang it tassels more freely, and the fertility of its pollen at the beginning of the season is fairly good, though very poor later on. By virtue of this fact this variety may be used both as male and female parent. The size of stick is very often transmitted to its offspring. They frequently inherit, also, its good rendement. Their growth habit, however, is coarse, the eyes often protruding and in many the pith is dry. Germinations from crosses with this variety are usually few.

Preangerriet (Striped Mexican). The pollen fertility of this variety is about the same as that of Rose Bamboo. The percentage of germination is usually small. The rendement of its offspring varies greatly, but is often quite high. This variety transmits its good characters to its offspring to a greater extent than many others.

Black Cheribon (Louisiana Purple). This variety was extensively used in former years, especially with Chunnee and with Chunnee hybrids. Since the characters of the latter are strongly dominant, little is known as to the qualities which it transmits to its offspring. But little fertile pollen or none at all is pro-

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\* Now in quarantine at Honolulu.

duced on the lowlands, but at higher altitudes with lower temperatures and higher humidity and especially at the beginning of the season the pollen fertility may be fairly high. The growth habit of its offspring is fairly good, their rendement likewise. On the whole, however, this variety is considered inferior to Striped Mexican for crossing purposes.

Lahaina. This variety is highly esteemed as a female parent in crosses. It tassels rather scantily in the warm lowlands, but more frequently in the cooler and moister regions. It has a strong tendency to transmit its high rendement to its offspring, but associated with it is a weak root system and susceptibility to mosaic. Many of its offspring have large sticks, but they are often coarse or weak. The nodes are often short and poorly shaped, and the root eyes frequently show a tendency to sprout. On account of its high rendement, however, Lahaina remains an important variety in the crossing program.

(*In addition to the above varieties the author discusses also the breeding qualities of many not found on these Islands.*)

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## Sugar Prices

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**96° Centrifugals for the Period  
December 16, 1926, to March 15, 1927**

Date	Per Pound	Per Ton	Remarks
Dec. 16, 1926.....	5.08¢	\$101.60	Cubas.
" 22.....	5.05	101.00	Cubas.
" 29.....	5.065	101.30	Cubas, 5.08; Porto Ricos, 5.05.
" 31.....	5.15	103.00	Cubas.
Jan. 3, 1927.....	5.21	104.20	Cubas.
" 5.....	5.165	103.30	Cubas, 5.18, 5.15.
" 7.....	5.12	102.40	Cubas.
" 12.....	5.05	101.00	Cubas, 5.08, 5.02.
" 14.....	5.005	100.10	Cubas, 5.02, 4.99.
" 17.....	4.96	99.20	Cubas.
" 19.....	4.915	98.30	Porto Ricos, 4.90; Cubas, 4.93.
" 20.....	5.02	100.40	Porto Ricos.
" 24.....	4.90	98.00	Porto Ricos.
" 26.....	4.93	98.60	Cubas.
" 27.....	4.99	99.80	Porto Ricos, 4.96; Cubas, 5.02.
" 28.....	4.90	98.00	Cubas.
Feb. 1.....	4.89	97.80	Porto Ricos, 4.91, 4.86; Cubas, 4.90.
" 3.....	4.83	96.60	Porto Ricos.
" 5.....	4.96	99.20	Porto Ricos.
" 8.....	4.90	98.00	Porto Ricos.
" 9.....	4.945	98.90	Porto Ricos, 4.93, 4.96.
" 16.....	4.90	98.00	Cubas.
" 23.....	4.945	98.90	Porto Ricos, 4.93, 4.96.
" 28.....	4.90	98.00	Cubas.
March 8.....	4.915	98.30	Porto Ricos, 4.93; Philippines, 4.90.
" 12.....	4.86	97.20	Porto Ricos.
" 14.....	4.83	96.60	Cubas.
" 15.....	4.77	95.40	Porto Ricos, Philippines.

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# THE HAWAIIAN PLANTERS' RECORD

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## Nematode Parasites of Termites

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BY R. H. VAN ZWALUWENBURG

Mr. Pemberton's importations of nematode worms of the genus *Rhabditis* found within various termite species in Celebes and North Borneo, have renewed interest in the possibility of finding parasites effective against the notorious *Coptotermes formosanus* Shiraki (= *C. intrudens* Oshima) now so destructive in Honolulu.

Records in literature, of nematode worms in termites, are few. Mr. Muir has already (*The Hawaiian Planters' Record*, April, 1926) called attention to a paper by Lespés (*Ann. Mag. Nat. Hist.* 2nd Ser. XIX, p. 388) in which he discusses *Isacis migrans* parasitic upon termites and causing their death.

In 1919, Theiler, working in South Africa, described *Filaria gallinarum*, a nematode attacking barnyard fowls, which requires an intermediate host, the worker of *Hodotermes pretoriensis* Fuller for its complete life-cycle. This is a ground-inhabiting termite which forages above ground during the day; the larval stage of the *Filaria* lives in the abdomen of the worker caste only. Infested termites are eaten by chickens, the nematode develops to full maturity within its new host, and produces eggs which are later passed out by the fowl. It is believed that the eggs hatch after being swallowed by the termite worker and the nematodes find their way into the coelomic cavity of the insect.

These observations are of especial interest to us, because they suggest a possible reason why efforts have so far failed to breed this Celebes species of *Rhabditis* (which Mr. Pemberton found only as larvae within the abdomen of its termite host): due to the absence in these Islands of the alternate host necessary for the completion of the nematode's life-cycle. We do not know what the essential alternate host is in this case, or even that an alternate host is necessary. These observations show that a greater knowledge of the life-cycle of each nematode species is of the utmost importance before we can hope to establish them as parasites on our termites.

The South African termite-chicken nematode is not stated to be an important death factor of the termites. There are, however, other nematodes which do cause the death of termites. *Reticulitermes lucifugus* (Rossi) of the United States is parasitized by *Diplogaster acrívora* Cobb (or a closely related species) which occurs in the head only, and in heavy infestations causes the termite host to become sluggish and often to die. (Snyder, Bull. 108, U. S. Nat. Mus., 1920, p. 117.) The same termite is similarly affected by infestations of *Rhabditis janeti* (Lac.-Duth.) which also confines itself to the head of the host. In the rubbish of nests of the same species, two other nematodes were found: *Rhabditis dolichura* (Schneider) and *Diplogaster attenuatus* Cobb (?); "they are probably very common feeders on decaying organic matter."

Ruttledge (Parasitology, Vol. 17, 1925, p. 187) records a nematode of the family Mermithidae, in the body of the South American *Cornitermes orthocephalus* Silv. Its effect upon the host is not stated, though worms of this family usually cause death of their insect hosts.

Linstow (Jena. Zeitsch. Naturw. 1901, n. s. XXVIII, p. 418) describes another Mermithid, *Spinifer fulleborni*, from a termite nest near Lake Nyassa, Africa. This is also presumably a true parasite.

E. Hegh in 1922 (Les Termites; partie générale; Brussels, p. 598) records a *Mermis* found by Silvestri in the abdominal cavity of a soldier termite, *Thoracotermes brevinotus* Silv., in French West Africa.

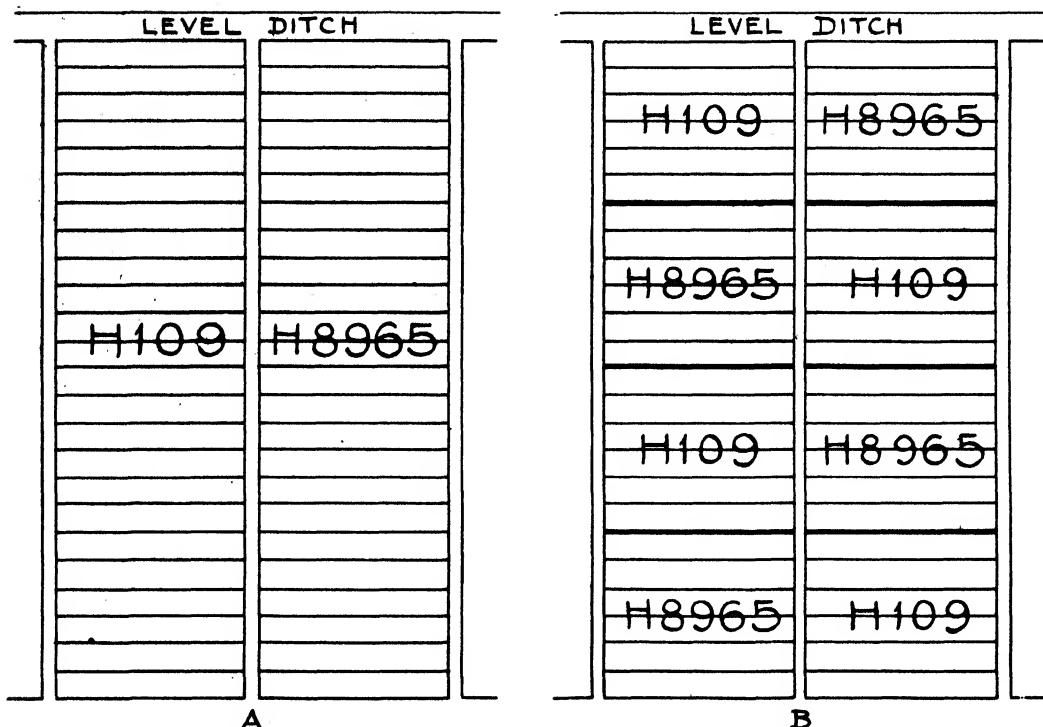
## Variety Testing

By J. A. VERRET AND A. J. MANGELSDORF

That check plots or replications are essential to reliable results in yield trials is now generally recognized, so far as fertilizer experiments are concerned. It appears that this is not the case, however, in variety testing. We still find attempts being made to arrive at the comparative yielding ability of two varieties from the yields of single watercourse or level ditch plots. That such a procedure may be misleading in the extreme, even though the two plots are side by side, is obvious when one considers the variations in yield between adjoining watercourses and level ditches planted to one and the same variety, under the same treatment.

It is not strange that the necessity for check plots and replications has come to be realized in fertilizer trials sooner than in variety tests. In the former, inconsistencies in yield are easily seen. The following example will serve to illustrate:

Plot No.	Pounds Nitrogen Applied	Yield Tons Sugar per Acre
1	150	8.6
2	175	8.5
3	200	9.4



Two ways of utilizing the same area in a variety test. The first is easier to harvest, but the time and labor expended in obtaining yield data on such a layout are largely wasted, since very little reliance can be placed on the figures obtained. The second layout requires more care and supervision in harvesting, but the figures obtained should give a fairly reliable indication of the relative yields of the two varieties under the conditions of the experiment.

We are struck at once with the fact that the data are inconsistent—the necessity of replications to offset soil variation, if reliable figures are to be obtained, is obvious.

Turning now to variety tests, we obtain for example, from three plots the following data :

Plot No.	Variety	Yield Tons	Sugar per Acre
1	U. D. 1	3.9	
2	U. D. 110	3.7	
3	K 202	1.9	

We are likely to accept these data as actually indicating the relative yielding capacities of the three varieties, in spite of our knowledge that single plot trials are no more likely to give us reliable results in variety tests than in fertilizer tests. The reason for our less critical attitude toward the results of variety tests no doubt has its roots in the fact that we have no basis on which to detect the inconsistencies.

Very little reliance can be placed on figures obtained from experiments like the one just described. It is true that if single plot trials of this kind are repeated, let us say, for three successive years, each year in a different location, the results taken together are fully as reliable as those from a single trial with three replications. Unfortunately, however, this is seldom done.

The remedy is, of course, known to all of us. There must be a sufficient number of check plots, or replications, or both, to insure reliable results. One check plot of a standard variety to two of the varieties being tested, with the entire series repeated at least once, is about the minimum upon which any reliance can be placed. The more variable the soil or moisture conditions, the more replications will be required to obtain the same degree of reliability. If check plots are not used the series should be repeated at least twice (three replications). The greater the number of replications the more dependable the results, other things being equal.

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## Molasses as a Fertilizer to Cane Soils in Mauritius

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In Bulletin No. 28, General Series of the Department of Agriculture, Mauritius, 1923, "The Application of Molasses as a Fertilizer to Cane Soils in Mauritius," H. A. Tempany and France Giraud discuss this question. According to these authors, the practice of applying molasses to cane soils in Mauritius dates back to 1860 but it did not become general till about 1900.

In discussing previous work on this subject, they mention Peck's work in Hawaii and remark: "It is curious that from Hawaii no results, so far as the writers are aware, have been recorded for tests in the fields."

The usual practice in Mauritius is to apply 4 tons or 836 gallons per acre, but the quantity varies and as much as 15 tons per acre have been applied.

The following are their general conclusions:

1. Planting practice in Mauritius favors the application of molasses to cane fields and evidence goes to show that such applications occasion considerable increases in yield. Rates of application range from 4 to 15 tons per acre.
2. The correctness of this view was originally indicated by experiment conducted by Boname and confirmed by experiments in Java. These observations have since been further confirmed by two separate sets of experiments, the results of which indicate that in virgin canes the increase in yield resulting from applications of molasses under the conditions of experiment may be expected to amount to 9.65 tons of cane per acre.
3. Considerations drawn from other experiments show that these increases are too large to be attributed entirely to the plant food conveyed by the molasses to the soil; consequently some other contributing cause must be sought, this is probably biological in nature.
4. Ebbels and Fauque have suggested that stimulation of nitrogen fixation by Azotobacter in consequence of the addition of sugar is the explanation. This, however, is denied by de Sornay. In point of fact the action of Azotobacter is very variable and is liable to be affected by other activities of the nitrogen cycle of which it forms part.
5. The presence of Azotobacter in Mauritius soils has been demonstrated and its activity estimated.
6. Continuous laboratory investigations extending over more than one year have, however, shown that on ordinarily rich soils addition of molasses does not increase the rate of nitrogen fixation, although it may evolve more active strains of Azotobacter.

7. On the other hand Azotobacter is apparently an important factor in soil maintenance and enrichment; but in presence of the abundant supplies of organic matter and nitrogen usually present in Mauritius soils it appears that addition of molasses usually fails to stimulate nitrogen fixation. On poor soils it is possible that the effect would be different.

8. The most marked action of molasses applications is in relation to nitrification; after molasses is applied this process is entirely suspended and in addition nitrates primarily existing in the soil disappear, being apparently reverted to the insoluble form.

9. It appears that one of the principal effects of molasses application is the partial sterilization of the soil in consequence of which the ordinary soil organisms are for the time being greatly reduced in numbers while other organisms, notably moulds and torulae, are stimulated. The latter may be of importance in relation to reversion of nitrogen to the insoluble form.

10. Subsequently nitrification is resumed at an enhanced rate and probably leads to accumulation of nitrates just at the time they can best be utilized by the growing plant.

11. The tendency of ammonia and nitrates to revert to the insoluble form is very marked in Mauritius soils and it seems not unlikely that molasses applications may have the effect of neutralizing to some extent applications of nitrogenous fertilizer by causing their nitrogen to revert in this way.

12. In addition the following other effects may be present and operative in a greater or less degree:

- (a) The direct effect of the plant food added in the molasses.
- (b) Liberation of plant food from unavailable reserves owing to fermentation actions.
- (c) Improvement in the physical conditions of the soil owing to flocculation of the clay particles by molasses.

13. Regarding the effect of molasses applications observed on subsequent crops of ratoon canes, it is believed that it is to be attributed more to the increased vigor imparted to the virgin canes than to persistence of favorable conditions in the soil.

14. Owing to the effect which molasses can exercise on the biological process of the soil it is important that they should be applied in such time and in such manner as not to cause injury to growing crops.

If this precaution is neglected considerable harm may result inasmuch as molasses, causing as it does a complete temporary arrest of nitrification and reversion of nitric nitrogen to the organic form, can, if applied to soils in which canes are in full vegetation, do considerable damage.

In the foregoing pages the position in relation to this important and intricate problem has been reviewed at length and the results of further experimental work recorded. It is believed that although certain points admittedly remain obscure a good deal has been done to throw light on the question.

F. M.

## Notes on the Mexican Tachinid, *Archytas cirphis* Curran, Introduced Into Hawaii as an Armyworm Parasite

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By O. H. SWEZÉY

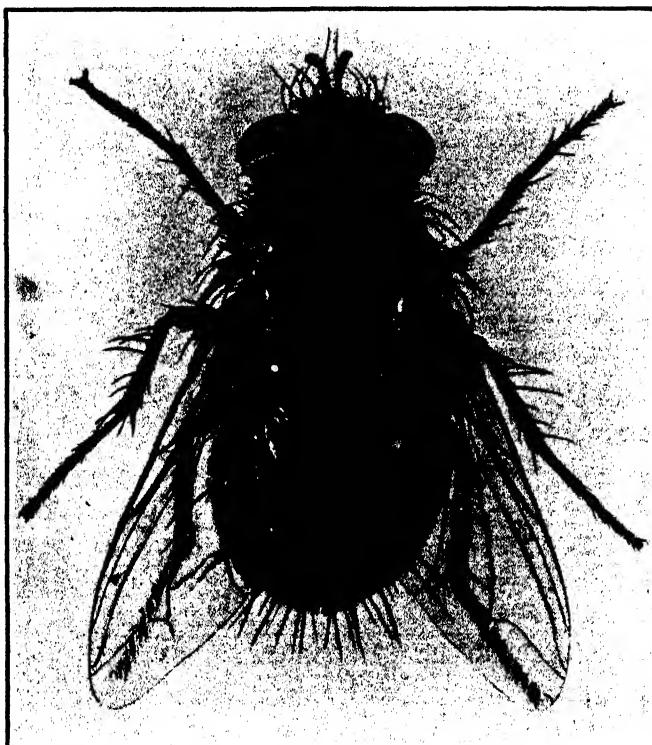
This Tachinid fly was introduced from Mexico in 1924. H. T. Osborn found it parasitizing *Cirphis latiuscula* (Herr.-Sch.) in sugar cane fields at Los Mochis, Sinaloa, Mexico. A batch of parasitized chrysalids was received from Mr. Osborn February 12, 1924, from which fifteen flies issued February 12 to 26. Nine of the flies were liberated February 25 at the Federal Agricultural Experiment Station where there were armyworms in an area of nut grass. No attempt was made at rearing them in the insectary.

The first intimation that this Tachnid had become established was on February 20, 1925, when Dr. Williams observed one or two in the Experiment Station grounds not far from the original liberation. Thereafter a lookout was kept for them whenever opportunities occurred, and recoveries were made as follows, showing wide distribution on Oahu and first appearance on the other islands:

### DATES AND PLACES OF RECOVERY

- 1925. February 20. Federal Experiment Station, Honolulu. (Williams.)
- February 23. Manoa Cliffs Trail on Mt. Tantalus, about 1500 ft. (Swezey.)
- March 10. Experiment Station, H. S. P. A., inside on window. (Williams.)
- March 28. Thurston Ave., Honolulu, numerous on milkweed. (Rosa.)
- April 21. Federal Experiment Station, very numerous on corn. (Rosa.)
- May 15. Ewa Plantation, Field 9, 3 flies on weeds. (Swezey.)
- June 11. 2048 Lanihuli Drive, Manoa, 1 fly in garden. (Swezey.)
- June 21. Mt. Tantalus, Twin Peaks, 2 flies on Hilo grass. (Swezey.)
- June 29. Tree nursery in Makiki Valley, 2 flies on Alternanthera. (Hadden.)
- July 4. Mt. Tantalus, near Mrs. Swanzy's, 2 flies on grass. (Swezey.)
- July 12. Waimanalo, Olomana Needle, near summit, 1 fly. (Swezey.)
- July 19. Opaeula about 1500 ft., in forest, several flies. (Swezey.)
- August 16. Mt. Kaala, mauka of target range. (Williams.)
- October 3. Oahu Sugar Co., Field 14B. (Swezey.)
- October 9. Waialua Agricultural Co., Field Mill 9. (Williams.)
- October 12. Waialua Agricultural Co., Field Gay 3. (Swezey.)
- October 11. Sacred Valley, windward Oahu. (Hadden.)
- October 26. Waialae Ranch. (Swezey.)
- 1926. March 4. Maui, Hawaiian Commercial & Sugar Co., Field E, numerous. (Muir.)

- March 5. Maui, Wailuku Sugar Co., near Field 97, numerous. (Van Zwaluwenburg.)  
 March 5. Maui, near Sanitarium in Kula. (Muir.)  
 March 16. Wailupe, Hind-Clarke Dairy. (Hadden, Swezey.)  
 March 30. Kualapuu, Molokai, at G. P. Cooke's residence. (Wilder.)  
 May 9. Hilo, Hawaii, Hilo Hotel garden and at cemetery. (Swezey.)  
 June. Molokai, in pineapple fields. (Illingworth.)  
 1927. February 9. Kauai, Lihue Hotel grounds. (Williams.)  
 February 9. Kauai, Lihue Plantation, Field L4. (Williams.)  
 February 10. Kauai, Kilauea Plantation, Field 15. (Williams.)  
 February 13. Kauai, Summit Camp on Electric Power Line trail. (Williams.)  
 April 3. Palehua, south end of Waianae Mts. (Swezey.)  
 April 10. Kolekole Pass, Waianae Mts. (Swezey.)



*Archytas cirphis*, the Mexican Tachinid armyworm parasite. X5.

#### DISTRIBUTION TO OTHER ISLANDS

In April, 1925, when the flies appeared numerous on corn (attracted to honey dew from aphids and leafhoppers) at the Federal Experiment Station, an attempt was made to distribute them to the other islands. A colony of forty flies was captured and sent in a large carton by mail to Olala Sugar Company, April 21. None of them survived the trip. No further attempts were made till July, when Mr.

Van Zwaluwenburg, who was making an inspection trip to Kauai, took along 21 that had been captured. Ten of them survived the trip. These were liberated in the garden at the Lihue Hotel. Apparently these were sufficient to give them a start, for they were found in several widely separated places by Dr. Williams in February, 1926.

On September 8, 1925, and March 16, 1926, colonies were collected and sent by L. W. Bryan when he was returning to Hilo. Of these, six and eleven, respectively, survived and were liberated, and served to effect the establishment of the parasite on Hawaii. A few flies were recovered by the writer, May 9, 1926, on flowers in the Hilo Hotel garden and at the Hilo Cemetery. As yet the fly has not been recovered at any other locality on the island of Hawaii, but no doubt it is quite widely spread by this time.

No effort was made to distribute this fly to Molokai or Maui, but it reached these Islands somehow, as shown by the dates of recovery above in March, 1926.

#### LIFE HISTORY NOTES

No attempts had been made at rearing this fly, and its larvipositing habit was not known till on September 3, 1926, when a fly was observed to deposit a tiny maggot on a leaf of Bermuda grass on a ditch bank in Field Mill 9 of Waialua Agricultural Company. The leaf with this maggot was collected, and at 8 a. m. the next day it was transferred to a half-grown caterpillar of *Spodoptera mauritia*, the nut grass armyworm. The transference was made by placing the piece of grass leaf in contact with the caterpillar. As soon as the maggot came in contact with the surface of the caterpillar it became active and soon shifted to the surface of the caterpillar. It almost immediately located transversely in the segmental wrinkle anterior to the first abdominal proleg, on the left side. It remained in this position until about four hours later when it was found to have penetrated half way into the caterpillar. When next observed two hours later it had entirely disappeared and there was a black dot at place of entrance. Five days later the caterpillar pupated, and later on it showed a black spot on base of right wing sheath, where it was presumed that the parasite maggot was located. However, at the end of twelve days a crippled moth issued, showing that the parasite larva failed to develop.

In September, 1926, several flies were captured in the field, and confined in a cage with growing grass, but without any caterpillars. After a few days, on examination, quite a number of the tiny maggots were found on the grass leaves. In most cases they were near the margin of the leaf and parallel to it. A number of attempts were made at rearing these maggots through to adult flies, but only a few were successful. Out of fifty-five of the maggots that were transferred to caterpillars of *Spodoptera mauritia*, only four developed to adult flies. This was sufficient, however, to indicate the length of life-cycle.

In one instance, nineteen of the maggots were transferred to caterpillars, one to each, on September 28. On October 5 to 6 the caterpillars were pupating. On October 17, some moths were found to have issued and died. Three chrysalids

were found to contain puparia of *Archytas*, one in each. From these the adult flies issued October 26-28, making twenty-eight to thirty days from the time of transference of maggot to caterpillar. In another instance it was thirty-one days to the emergence of the fly from the puparium.

It is known that the fly produces a large number of maggots, but it must be that a very high percentage of them perish because of the small chance of a host caterpillar coming within reach. Yet, on the island of Oahu, *Archytas cirphis* has been able to keep up its existence, even though host caterpillars are apparently scarce, as there has not been any outbreak of these caterpillars since the first liberation of the flies occurred. It has not been determined how long the flies can live. Apparently there could be a new brood each month throughout the year, though the life cycle would no doubt be lengthened in the cooler part of the year, the same as is known with others of our insects.

Thus another armyworm enemy is permanently established and widely spread in the Hawaiian Islands and a valuable addition to the following list of introduced parasites on armyworms in Hawaii:

Tachinidae, *Frontina archippivora* Will. From U. S. A.

• *Chaetogaezia monticola* (Bigot). From U. S. A.

*Archytas cirphis* Curran. From Mexico.

Ichneumonoidea, *Amblyteles purpuripennis* (Cress). From U. S. A.

*Amblyteles koebbelei* (Swezey). From U. S. A.

*Hyposoter exiguae* (Vier.). From California.

Proctotrypid Egg-Parasite, *Telenomus nawai* Ashm. From Japan.

Chalcid-Fly, *Euplectrus platyhypenae* Howard. From Mexico.

## Investigations of Natural Enemies of Borers Allied to the Sugar Cane Borer *Rhabdocnemis obscura* Boisd. In the East India Archipelago

FEBRUARY, 1925-MARCH, 1927

By C. E. PEMBERTON

On February 13, 1925, the writer left Honolulu en route to the Philippines and the Malay Archipelago to investigate natural enemies of the sugar cane borer *R. obscura*, or borers allied to it, with the special object of finding, if possible, natural enemies other than the Tachinid parasite *Ceromasia sphenophori* Vill., found in Amboina, Ceram and New Guinea by Mr. Muir and successfully transported to Hawaii in 1910. As planned, the region requiring special attention was the island of Celebes.

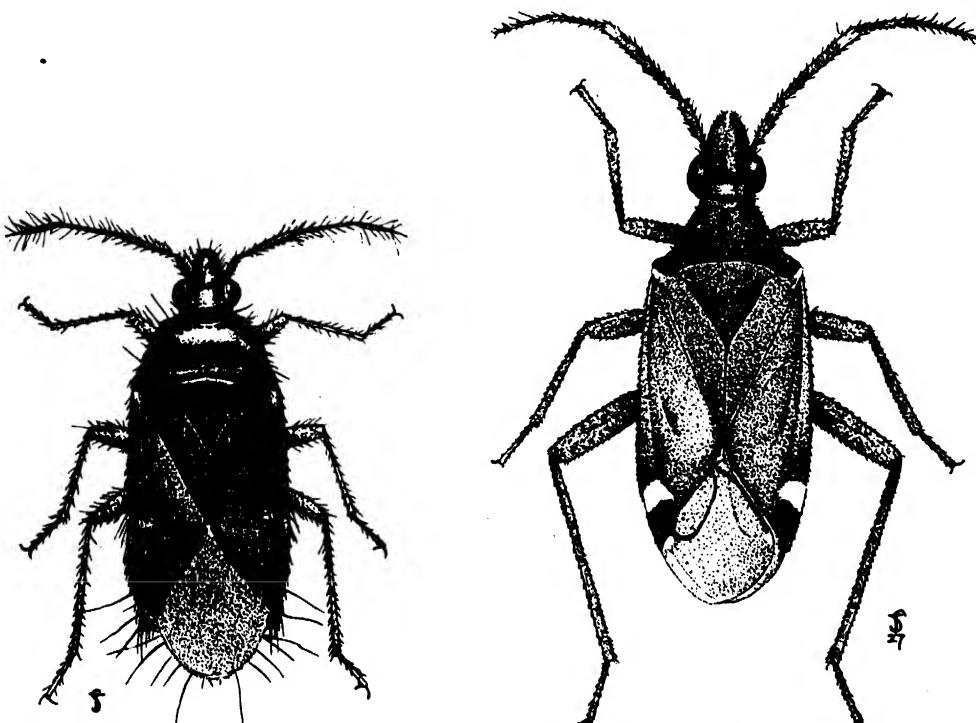
Before proceeding to Celebes, it seemed desirable to stop in the Philippines long enough to obtain shipments of a Larrid wasp, *Larra lusonensis* Rohwer, which, in 1917, was there found by Dr. F. X. Williams to be parasitic on the mole cricket *Gryllotalpa africana* Beauv. Williams' experience with this wasp indicated that a successful establishment of it in Hawaii would probably require the shipment of a good number at one time. With this object in view, living quarters were secured on the grounds of the College of Agriculture at Los Baños, P. I., and a search was commenced for the wasp in the open fields at the base of Mt. Makiling. After seven weeks of constant search in these fields without success, one female wasp was finally seen and caught in a cornfield on April 29. It was feeding on the sweet honey dew excretions of plant lice. This suggested a method for obtaining more. A concentrated solution of sugar and water was daily thereafter made up and sprayed on some of this corn. In a few days this resulted in the attraction of quantities of ants, bees, flies and wasps, among which would occasionally appear a female of the mole cricket parasite. A total of 19 females were soon caught and breeding operations were immediately started. As soon as a few females were obtained, search was made for a locality where mole crickets could be collected in quantity. At first this also became a problem, but after a few weeks of strenuous digging in the mud along the banks of the Molawin River, in flooded rice fields, etc., a place was finally found on the swampy borders of Lake Laguna, near Los Baños, where mole crickets could be obtained in fair numbers.

By confining the wasps singly in glass jars containing an inch or two of moist sand and a few fresh leaves, daily sprinkled with droplets of honey and water, they could be kept alive and active for several weeks. Individual mole crickets were placed in these jars once or twice daily. As soon as parasitized by the wasps, they were removed and placed in two-ounce ointment tins filled with moist soil and shipped to Honolulu. Three successive lots were sent. By such a method the parasite reached Hawaii in the cocoon stage. Advance information obtained by Dr. Williams in 1921, was essential and useful in the conduction of this work to a rapid and successful termination. His original account of its habits appears in brief summary in *The Hawaiian Planters' Record*, Vol. XXXI, No. 1, pp. 4-6, January, 1927.

In all, 577 parasitized mole crickets were obtained and shipped to Honolulu by June 15. Of these 324 arrived in good condition. The wasps of both sexes emerged and were liberated on Oahu in upper Manoa Valley and at Ewa, Wai'alua and Kahuku plantations, where mole crickets were known to be present. These liberations insured the establishment of the wasp on Oahu, for at the present writing, March 22, 1927, the entomologists of the Station have found it at all localities of liberation excepting Kahuku, and Dr. Williams has even recovered it from Mt. Tantalus at an elevation of 1800 feet. It has also been seen at Waikiki well removed from the nearest point of original liberation. This wasp should, in time, contribute considerably towards a control of the mole cricket, especially since it can operate in Hawaii free from suppression by its own natural enemies, such as attack it in the Philippines.

While at Los Baños, one shipment of nut grass *Cyperus rotundus* Linn., comprising 500 bulbs, containing larvae or pupae of the nut grass moth *Bactra truculenta* Meyr., or the nut grass weevil, found by Dr. Williams in 1921 in the Philippines, was made on March 25. Again in January, 1926, two shipments, totaling 1250 affected bulbs were sent. Insect material from these lots reached Honolulu alive and was liberated. The moth is now well established in nut grass about the Experiment Station grounds in Honolulu. The weevil is also established. Mr. Rosa recovered one individual from nut grass on the Station grounds April 29, 1927.

A species of Rhabdocnemis (*Rhabdocnemis lincatocollis* Heller) being endemic in certain palms in the Philippines and being allied to our cane borer *R. obscura*, decision was made to remain in the Philippines and study the natural enemies of this beetle before proceeding south to Java, Celebes, etc. Any parasites or predators it might have would be well worth a trial on *obscura*. This work was com-



Mirid bug, predatory on eggs of *Rhabdocnemis* in Philippines, Java, Celebes and Borneo.

Anthocorid bug, predatory on eggs of *Rhabdocnemis* in Philippines, Java, Celebes, and Borneo.

menced about June 16, 1925, and continued until March, 1926. The Philippine borer normally inhabits the thick, woody, leaf-stems or trunks of palms wherever splits, cuts or other wounds occur. It is most readily found in the bases of mature, drooping, splitting leaf-stems of the Philippine sugar palm, *Arenga pinnata* (Wurmb.) Merr. This tree is abundant and an important forest element on Mt. Makiling to an elevation of 1500 to 1800 feet.

Continued studies of this beetle ultimately revealed two parasites; one a Tachinid fly quite different from our *Ceromasia*, but of similar habit; and the other an *Ichneumon* wasp parasitic on the borer pupa. Both were rare and not sufficiently different in habit from *Ceromasia* to prove of likely added importance in Hawaii if introduced. Enough fly puparia were secured, however, to make a small shipment. Some of these reached Honolulu alive and were liberated by Dr. Williams at Honokaa. It is too soon to know the result. It is doubtful if it became established.

This Philippine borer appeared to be suppressed primarily by predatory enemies. These were found to be three species of Hydrophilid beetles, *Dactylosternum hydropophiloides* M'Leay, *D. dytiscoides* F. and *D. near cycloides* Knisch; one Histerid beetle, *Platysoma abruptum* Er.; one Elaterid beetle, *Agrypnus* sp.; a Leptid fly, *Chrysopilus ferruginosus* Wied.; an Anthocorid bug; a Mirid bug and a centipede. The larval stages of the Hydrophilids, Histerid, Leptid and Elaterid all prey upon the borer larva. The centipede has a similar habit. The small, active Anthocorid and Mirid bugs (see figures), both young and adults, suck the juices of the borer eggs. They probably feed on the eggs of other small insects for they were several times seen feeding on eggs of Acari. These egg-sucking bugs can be found in cracks, crevices, borer channels, trash, etc., about the palms where the beetles occur. They were not seen elsewhere. Of the predators, the Leptid fly seemed to be the most useful. Its larvae feed on all stages of borer grubs and can also penetrate the woven, fibre cocoon and destroy the pupa. This was several times observed. The fly is not specifically predatory on *Rhabdocnemis*, since it sometimes can be found abundantly present within banana stumps containing banana borers, *Cosmopolites sordida* Chev. However, during the entire period of borer investigation in the Philippines, Java and Celebes, the larvae of this fly were always found either amongst palm borers (*Rhabdocnemis* sp.) or the banana borer. It was never found in any other situation. It was not found in Borneo.

Between October 5, 1925, and February 9, 1926, ten separate insect shipments were made to Honolulu from the Philippines, composed of either Mirids, Anthocorids, Hydrophilids, Histerids or Leptids. All of these species, reached Honolulu alive, in fair quantities, and were liberated in the cane fields at Honokaa, excepting the Leptid flies which were all liberated in upper Manoa Valley and on Mt. Tantalus. The predatory centipede and elaterid, above mentioned, were not shipped, the latter being too scarce to collect in sufficient quantity for a satisfactory consignment, and it was considered inadvisable to introduce the centipede.

The great success of the introduced Mirid *Cyrtorhinus mundulus*, as an egg-sucking predator on the sugar cane leafhopper in Hawaii gives some hope for success with the Philippine Anthocorid and Mirid, which feed on borer eggs there.

It is yet too soon to know the results of these introductions. To date there is no proof that any of these borer enemies have become established. It is of interest that the Histerid *Platysoma abruptum* Er., included in the shipments from the Philippines, was also studied by Mr. Muir while in Amboina in 1907 and sent in quantity to Honolulu with Hydrophilids. These were liberated but never became

established and it is quite possible that the Philippine introductions may suffer the same fate.

Jepson originally recorded the feeding habits of the Leptid fly.

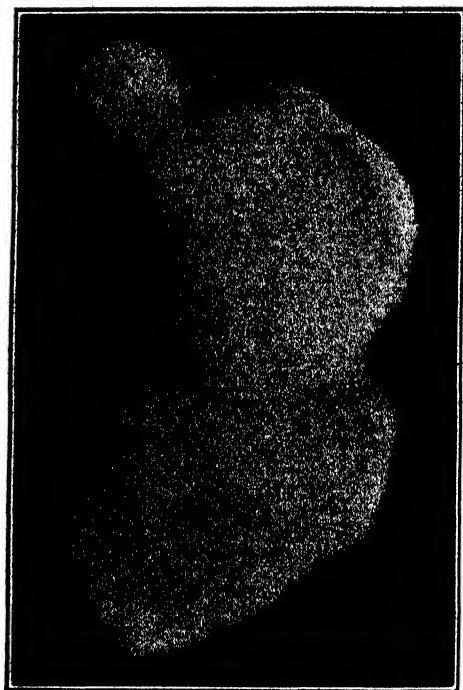
Finding nothing further of importance on *Rhabdocnemis*, after having examined quantities of eggs and thousands of larvae, pupae and adults on the mountain during the year, passage was secured from Manila to Java, via Singapore on March 12, 1926. Malaria was contracted at Los Baños, in the Philippines, shortly before leaving. This persisted for several months, after reaching the Dutch East Indies, in spite of treatment, and retarded general activities for short intervals. Using Buitenzorg, Java, for headquarters where ample laboratory facilities were kindly offered by the Dutch Government Department, especially the Instituut voor Plantenziekten, studies in West Java of *Rhabdocnemis leprosus* Fahrs., a Calandrid beetle allied to our cane borer, were begun. This work extended from April 2 to July 6, 1926. Regions were visited at various points within a radius of 150 miles of Buitenzorg, especially the mountainous interior to the south and east of this city, to an elevation of about 4,500 feet. The Java beetle was found boring in the woody leaf stalks and injured trunks of the East Indian sugar palm *Arenga saccharifera* Wurmb. None was found in sago palms or in sugar cane. The beetle was by no means common. Some weeks of searching were expended before any were found at all.

No parasites were bred during the entire period though a good quantity of eggs, larvae, pupae and adults were finally collected and examined in the places visited. The control factors appear to be solely fungous diseases and predatory enemies. The latter were the same or forms closely allied to those species found in the Philippines and sent to Hawaii. The egg-sucking Mirid and Anthocorid bugs, the Hydrophilids, Histerid and Leptid appeared to be the same and usually one or more of these were present where borers were found, if careful search were made. The scarcity of this borer in Java appeared to be owing primarily to the presence of a fungous disease of a type quite distinct from any found in the Philippines or already present in Hawaii. As noted below, an effective fungous disease somewhat similar to this was also found on *Rhabdocnemis* in North Celebes some months later. On a few occasions, while in Java, as high as 50 per cent of the borer larvae, pupae or adults found in *Arenga* tissue were dead with this fungus. This was shipped to Honolulu and found by the Station entomologists to develop successfully on *R. obscura*. Mr. Barnum, of the pathological department, has further demonstrated a high mortality amongst *obscura* larvae and adults exposed to this fungus and has succeeded in developing it also on other insects, especially roaches, which die usually within six days after inoculation. This and the Celebes fungus (see figures) have been propagated at the Station, and living, freshly infected beetles distributed to various plantations to facilitate its distribution.

Several weeks were spent at Buitenzorg, Java, in a study of a nematode often found massed on the under surface of the elytra and in the sutures of the dorsum



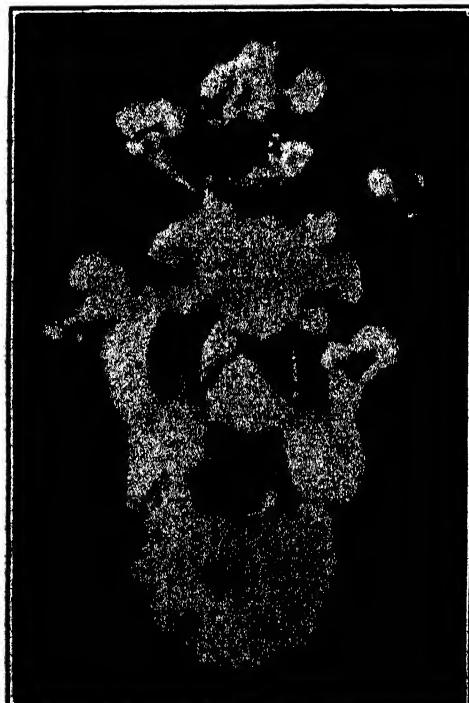
A



B



C



D

A—Celebes fungus. Early stage of development on *Rhabdoenemis* larva.

B—Celebes fungus. Advanced stage of development on *Rhabdoenemis* larva.

C and D—Celebes fungus. Advanced stage of development on *Rhabdoenemis* adult, dorsal and ventral views.

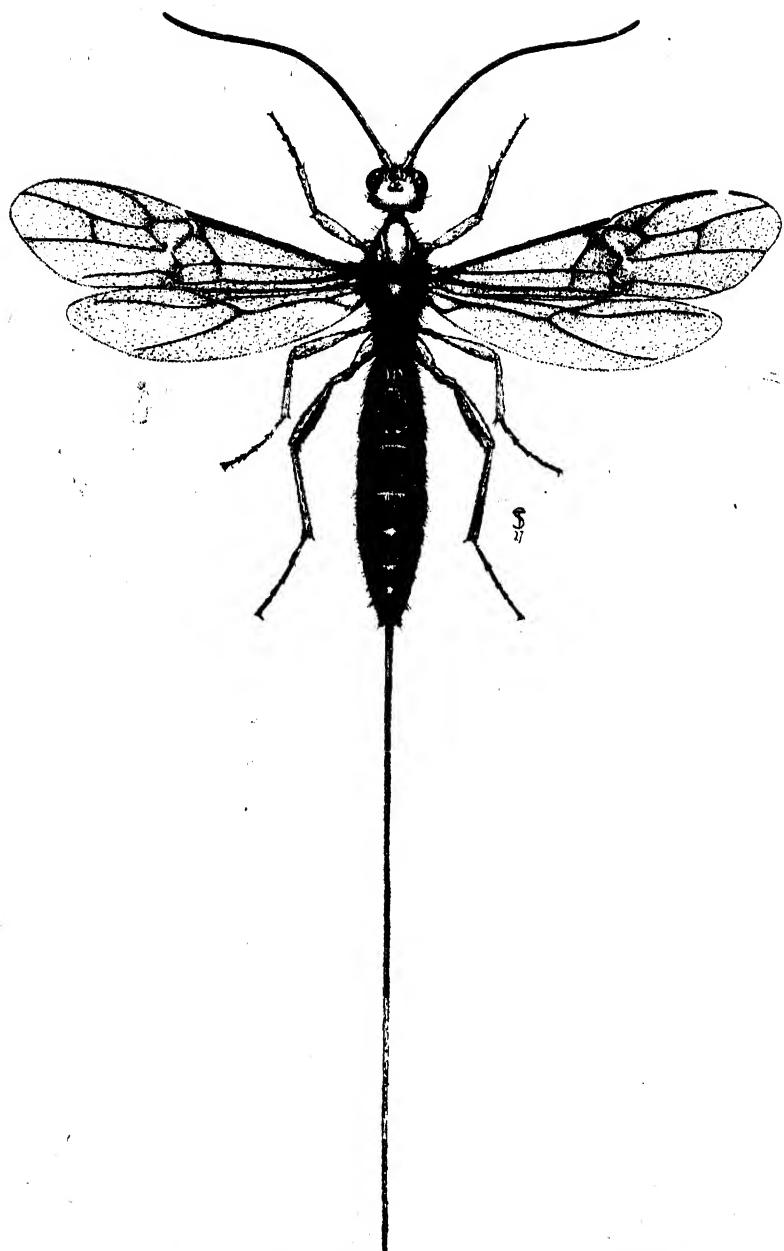
of the abdomen of living *Rhabdocnemis*, *Rhyncophorus* and *Sphenophorus* beetles. This was also found occasionally in dead larvae of *Rhabdocnemis* and *Sphenophorus*. The nematode developed most readily on the beetles after they had died. All experiments ultimately indicated that the nematode was more a scavenger in nature than a parasite.

A small *Sphenophorus*, abundantly present in fermenting sago palm stumps, was collected in quantity but no parasites were reared. The predatory and fungous enemies above noted on *Rhabdocnemis* appeared to be the most important control factors. This includes the egg-sucking bugs.

Passage was secured from Batavia, Java, to Menado, North Celebes, on July 7, 1926. After a voyage of 17 days with many stops, headquarters were established in a small Dutch hotel at Menado. In a few days' time a *Rhabdocnemis* very similar to *R. obscura*, was found in sugar palms near Menado. A fine forest, well stocked with sugar palms, as shown in the accompanying illustrations, was located about 12 miles from Menado, where the beetle was found in fair abundance. After securing the necessary authority from the Dutch Resident of the district and proper introductions to the native chief of the village of Tateli, adjacent to the forest, an intensive study was begun in this locality. A native guide, self-appointed, was obtained who occasionally proved useful. This work continued without interruption from July 24 to September 5. This region, being only about 2° north of the equator and at sea level, was considerably warmer than any locality previously visited.

The *Rhabdocnemis* found in sugar palms about Menado evidently attacks sugar cane rarely. The natives positively stated, in several instances, that this beetle bores in sugar cane sometimes. Only small patches of cane were found in Celebes, constituting usually a few stools in native villages. One stalk was found bearing old borer channels, but no cocoon or larval exuviae could be seen.

On the *Rhabdocnemis* in the Tateli forest a large Braconid pupal parasite was found (see figure). There were indications that it may also develop on the mature grub. This wasp has an ovipositor of from one-half to three-fourths of an inch in length, with which it is able to sting, paralyze and oviposit upon the borer grub or pupa. The egg is placed upon the body surface. The egg hatches in from 3 to 4 days, the small larva then feeding on the surface of the grub, rapidly growing and emptying the host of its body juices. Maturity is reached in about 6 days. A silken cocoon is spun within the borer cocoon and the adult wasp emerges in about 12 days more. This was under Menado temperatures with a daily average maximum in the hotel room of about 90° F. and a minimum of 75° F. The finding of this parasite, so different from anything yet uncovered, raised great hopes for its utilization since it attacked the pupa and should harmonize well with the larval parasite *Ceromasia* already in Hawaii. Such expectations were ultimately shattered, however, because of the great scarcity of this wasp. Only ten individuals were reared between August 1 and October 15, and only 2 were seen and caught in the forest. Never at any one time were more than 3



Braconid wasp, parasitic on pupa and mature larva of *Rhabdocnemis* in North Celebes.

living females available for cage breeding and they could not be induced to oviposit satisfactorily in captivity. A large cage was constructed for this purpose but only a few successful ovipositions were secured. The scarcity of this parasite was manifest by the collections and examinations of several thousand borer cocoons dug out of palm leaf stalks during residence in North Celebes. This Braconid must be under heavy suppression by natural enemies, though no secondary parasites were reared from the few parasitized borer pupae collected. The wasp has a slow, labored undeviating flight and must fall a ready prey for birds, certain predatory insects and even lizards, which abound. It may also possibly parasitize some other undiscovered Calandrid in the forest.

No other parasites were found; but predatory enemies almost identical with those shipped from the Philippines were abundantly present, especially the two egg-sucking bugs and the Leptid fly. Perhaps the most effective check of the borer in North Celebes is a fungous disease somewhat similar to the one found in Java, as mentioned above. Dead beetles, larvae and pupae were easily found bearing this fungus. Many were collected and used for inoculating a good quantity of living beetles and grubs. These became inoculated simply by contact with the powdery masses of spores on the dead ones. A high percentage, thus inoculated, died in from 6 to 10 days. This fungus was shipped to Honolulu and, as mentioned above, Mr. Barnum has succeeded in propagating it on *obscura* with high degrees of mortality. There is a bare chance that it may prove as effective in Hawaii as in Celebes, after a sufficient lapse of time for its distribution. Wet conditions favor its development and consequent spread, though it was found and collected in Celebes during the periodic six months dry season.

A week's trip was then made on a small Dutch steamer to various islands in the Celebes Sea extending north by east about 200 miles. Visits were made to the islands of Tagolanda, Siao, Sangir and the Talauer Islands. This region lies in a more or less direct line between the Molucca Islands and Mindanao Island in the Philippines. The islands are much isolated and each is surrounded by deep sea. No species of *Rhabdocnemis* were found on any, nor were suitable host plants present, such as sugar palms, sago palms and sugar cane, excepting in a few rare cases. The entire group is heavily planted to coconuts.

While on Sangir Island, opportunity was had to observe the complete destruction of several hundred acres of mature coconut trees by an introduced coconut pest *Aspidiotus destructor* Sign. As existence among the natives on this island depends almost entirely on their copra trade, they, and the one white inhabitant, a Dutch official, were much alarmed, for the insect was rapidly spreading from the one point of devastation. Time was had to examine some of these trees and to demonstrate the total absence of parasites or important predators. As a result, well known parasites of this pest, long known in Java, are now being sent to Sangir by Mr. Leefmans, of the Dutch Entomological Service.

The islands of Siao, Sangir and Tagolanda bear one or more great, smoking, semi-active volcanoes of tragic history in relation to the native inhabitants. Thriving native villages were encountered on the very slopes of these steaming, smoking cones.

Returning to Menado, the elevated interior of North Celebes was next visited. On Tondano Lake, at an elevation of 2250 feet, sago swamps were numerous along its borders. In these palms, an additional species of *Rhabdocnemis* was fairly common. Several thousand larvae, pupae and adults were examined, together with a fair lot of eggs. Only 3 more pupae were found parasitized by the same Braconid as in the Tateli forest near Menado. The predators, already referred to, were all present, and borers dead with the same fungus were common. The Menado species of *Rhabdocnemis* was also found in various places in the elevated interior in sugar palms; but no control factors other than those about Menado appeared. These results in the interior were disappointing, since every effort was made to find a locality where the Braconid parasite could be found in greater numbers than in the Tateli forest.

Returning again to Menado, a study of the *Rhabdocnemis* in sugar palms at Tateli and about Menado was taken up again. This continued until October 16, 1926. No encouraging indications were discovered of additional enemies to those already studied and nothing further was seen of the Braconid wasp.

While in North Celebes some time was spent in the examination of termites for natural enemies. No effective parasites were found, though in two cases, small workers of a species of *Termites* were found to contain the larva of a fly within the abdominal cavity. Many subsequent dissections revealed no more. Nematodes were found present in the mouth cavity of certain termites. In the small workers of a species of *Termites*, a nematode inhabiting the abdomen outside of the intestinal tract was frequently seen. There was no certain indication that these nema checked the termites to any marked degree. Shipments of these nematodes were made to Honolulu. Mr. Muir and Dr. Henderson have succeeded in developing a quantity of the intestinal nematode. They were placed with a colony of *Coptotermes* in the laboratory. Recent dissections of these termites showed no signs of nema infestation, however. The Celebes abdominal nematode is probably attached only to certain castes within a very limited group of termite species. None was found within *Coptotermes* in Celebes.

Departing from Menado on October 17, Macassar, the only city of Celebes worthy of the name, was reached in 5 days. The country for 40 or 50 miles around Macassar is flat and cultivated mostly to rice. The original forest was gone even in Wallace's time (1860). No sago swamps were found and only a few scattered sugar palms could be located and these were far from Macassar. When examined no *Rhabdocnemis* were present. This proved an unsuitable region to work in. The heat was intense and the whole country parched, dry and dusty, which probably accounted for the absence or scarcity of *Rhabdocnemis* in the palms at that time of year. No sugar cane was seen. A small forest reserve region on the Maros River, some 40 miles away, was located where termites could be found in abundance. Studies of these revealed nothing in addition to what was found in Menado.

Owing to infrequent steamship traffic between South Celebes and British North Borneo, it was necessary to remain in Celebes until November 18, when passage

was secured on a small Japanese freighter. This reached Sandakan, British North Borneo, November 22.

British North Borneo is largely covered with tropical forests. It is a region of abundant rainfall and rivers and small streams abound. Transportation is mostly by small steamers along the coast, and canoes, launches and motor boats on the rivers. No roads extend inland excepting one short road 11 miles in length from the small town of Sandakan. This road passes into forest country only a few miles from the town. For the most part North Borneo is in an undisturbed natural state and furnishes a happy hunting ground for the naturalist. Wild elephants have only in recent years caused consternation amongst laborers clearing the jungle within 8 miles of Sandakan, while crocodiles with a notorious and demonstrated esteem for human flesh, abound in the swamps and along the river banks in places. During the investigations described below, snakes of varied sorts and sizes, both poisonous as well as harmless, were frequently met with, especially forms which inhabit the foliage of trees, vines and shrubs.

The forests about Sandakan were immediately examined for palms. No sugar palms occur there and only small bits of sago palms were found on the east coast. No *Rhabdocnemis* were seen in this sago nor in the cultivated oil palm, *Elaeis guineensis* about Sandakan.

On November 28, transportation was secured on a small, 100-ton steamer to the north end of Borneo and to the island of Jambongan off the northeast coast. No palms were found at the north end of the island. Jambongan is inhabited only by natives. Examinations along the coast of this island, which is densely covered with forest down to the shore line, revealed neither sugar palms nor sago swamps.

Returning to Sandakan, transportation was again secured on this same boat around the north end of Borneo to the west coast where the small English town of Jesselton is situated. From this place a small railroad has been built along the coast through swamps and over many streams and rivers for the convenience of rubber planters. This railroad passes large sago swamps, some 20 to 30 thousand acres in extent. These natural swamps furnish ample carbohydrate food for the natives. The palm grows in standing, fresh water adjacent to the sea, forming a dense, almost impenetrable jungle 30 or 40 feet in height. By careful guidance on the part of two natives, these were safely entered and examined. A species of *Rhabdocnemis* was soon found in the thick leaf stems of these palms. The collection of a large quantity of borer material here indicated the absence of any parasites, and again the control factors seemed to be predatory insects of the same species or varieties found in the Philippines, Java and Celebes. No fungous diseases, however, were found on the Borneo borer. The egg-sucking Mirid and Anthocorid bugs, noted in the Philippines, Java and Celebes, predominated amongst the predators. Since nothing new was found in Borneo, no further shipments were made to Hawaii.

A short trip was made to the island of Labuan, off the northwest coast of Borneo. Sago swamps were found there but no *Rhabdocnemis* were discovered.

which is curious, considering its abundance in the swamps on the adjacent Borneo coast.

In the sago at Labuan and at Papar on the west Borneo coast, a fairly common, small Calandrid beetle (resembling *Diocalandra*) was found abundantly parasitized in the larval stage by a small Braconid wasp. This weevil is very much smaller than *R. obscura*. Attempts to breed this parasite on immature *Rhabdocnemis* larvae failed.

Returning to Sandakan on January 20, 1927, eleven days were spent in the forests nearby examining termites for parasites. Nematodes were commonly found in the mouth cavity of many termite species. Seventeen species in all were examined. Nema were present in most of them. None was found in species of *Eutermes*; but were abundantly present in two species of *Coptotermes*, the genus with which we are mostly concerned in Hawaii. In the case of one species of *Capritermes*, mounds were often found completely vacated. In attempting to explain this, the mouth-inhabiting nematodes were found in abundance in this species. Often a single head would contain as many as 20 active nema. A quantity of these infested termites was collected in the forest near Sandakan about January 27 and prepared for transportation to Honolulu.

Passage to Manila was secured on the Australian S. S. "Tanda" leaving Sandakan February 1. Five days were spent in Manila before departure for Honolulu.

Reaching Honolulu on March 3, it was found that the termite-nematodes, carried from Borneo, were still living. Many were present in the bodies of the termites which died in transit. All of the termites were dead. Dr. Henderson has examined this nematode and found it to be a species of *Rhabditis*. An experiment is now under way to infect *Coptotermes* with these nema. It is too early to know the results.

The accompanying illustrations of sugar palms in North Celebes are given to indicate their importance as a factor in the forests there. They form, in places, thickets of nearly solid stand. They are abundant and prolific in virgin forests not only in Celebes but in Sumatra, Java and the Philippines from sea level to 4,500 feet elevation. On Mt. Makiling, in Luzon, they do not thrive above 2,000 feet; but in the more tropical parts of the Malay Archipelago they extend much higher. The tree is hardy and seeds heavily. The sticky sap, tapped from the flowering stalk, is much cherished by the natives, wherever found, for its sugar content. This sap is collected in bamboo joints, boiled down to a point of crystallization and cooled into cakes and sticks of varying design, forming a delicate product equal or superior to maple sugar. This tree is well worth a trial in the lowland forests of Hawaii.

In conclusion, it should be stated that the general results of the expedition suggest, as originally felt by Mr. Muir, an Austro-Malayan rather than Indo-Malayan origin of *Rhabdocnemis obscura*. The regions visited were primarily selected beyond the territories concentrated upon by Mr. Muir, in order to avoid duplication of effort and to find, if possible; something entirely different in nature from the Tachinid parasite *Ceromasia sphenorophori*. The scarcity or complete absence of true parasites of *Rhabdocnemis* in Java, Borneo, Celebes and the Philip-

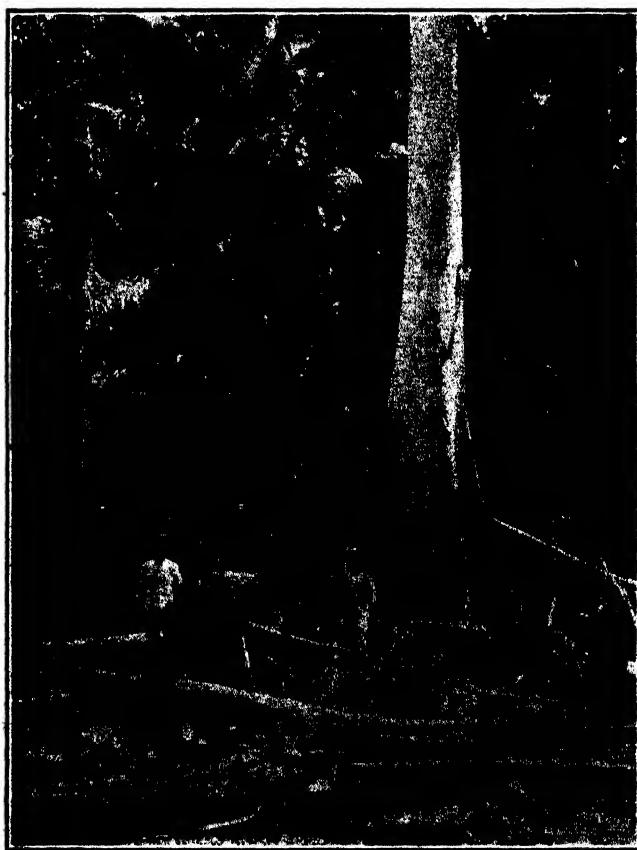
pines, as compared with the abundant parasitism by *Ceromasia* in Amboina, Ceram and New Guinea, further strengthens this view. On these three islands, Mr. Muir records a borer parasitism of 25 to 90 per cent, 58 to 90 per cent and 56 to 87 per cent, respectively.

During the present expedition, though thousands of borer larvae and pupae were collected in each place visited, no parasites at all were reared excepting in the Philippines and in Celebes and in these cases the percentage of parasitism was exceedingly low.

In case the predatory insects and diseases above discussed and shipped to Hawaii from Java, Celebes and the Philippines, fail to become established and future investigations are made in the Malay Archipelago of *Rhabdocnemis* enemies, the Austro-Malayan territory should afford the best chances for success. This includes New Guinea and adjacent islands, the Bismarck Archipelago and the Moluccas. As insect collections from this great area become more extensive, it is quite possible that the genus *Rhabdocnemis* will be found richer in species there than in the Indo-Malayan region.

Thanks are due Mr. C. F. Baker, dean of the College of Agriculture, Los Baños, Philippine Islands; Mr. S. Leefmans and Dr. P. Van der Goot, of the Instituut voor Plantenziekten, Buitenzorg, Java; and to Mr. H. G. Keith, Acting Conservator of Forests, British North Borneo, for courtesies, advice and assistance. We are also especially grateful to Mr. O. W. Pfueger, Chief of Division of Investigations, Bureau of Forestry, Philippine Islands, for much assistance in the collection of forest tree seed and in the preparation of insect cases used in shipping beneficial insects from Los Baños to Honolulu.

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Sugar palms, *Arenga saccharifera*, in background, at edge of forest, Tateli, North Celebes.



Sugar palms, *Arenga saccharifera*, at edge of forest,  
Tateli, North Celebes.



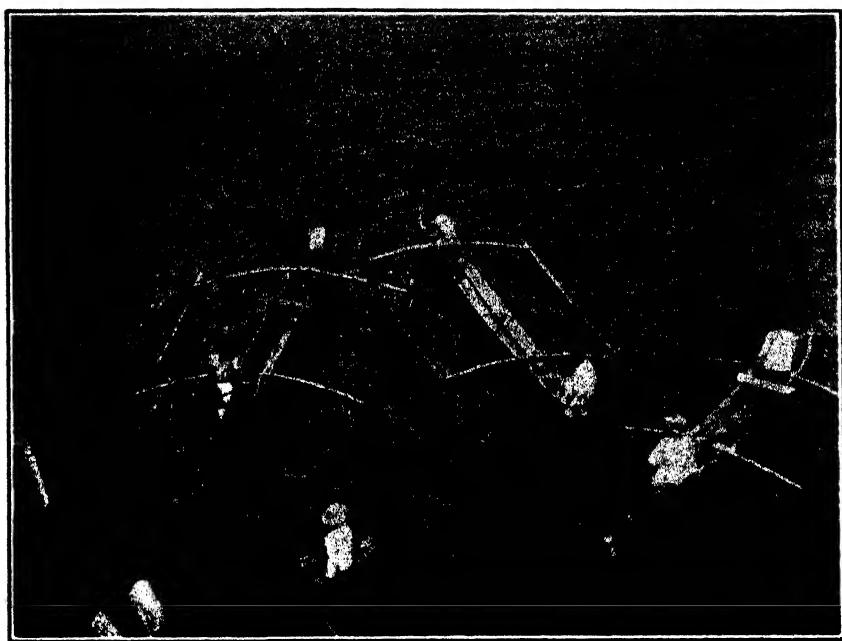
Sugar palms, *Arenga saccharifera*, in forest, Tateli,  
North Celebes.



Sugar palms, *Arenga saccharifera*, in forest, Tateli,  
North Celebes.



Road passing through forest of mostly sugar palms at  
Tateli, North Celebes.



Typical disembarkation facilities at many points visited in the Dutch East Indies.



Littoral vegetation at seacoast, North Celebes.



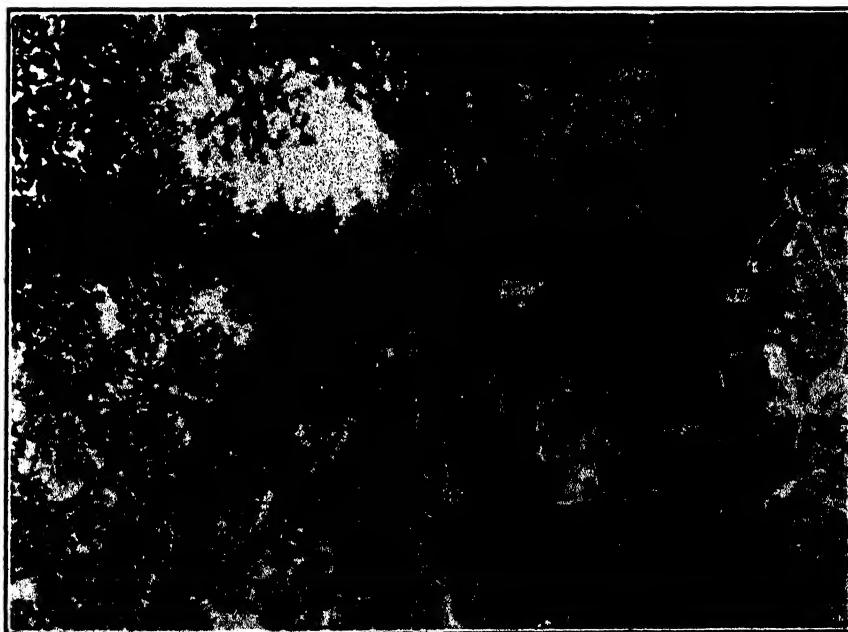
Showing typical crown of *Ficus minahassae*, Mt. Makiling, Philippine Islands.



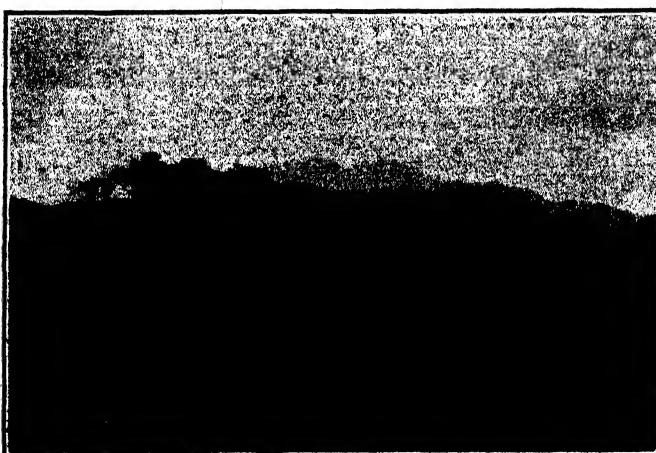
*Ficus nota*, at base of Mt. Makiling, Philippine Islands. Height 30 feet.



Edge of forest, Mt. Makiling, Philippine Islands.  
Teak seedlings in foreground.



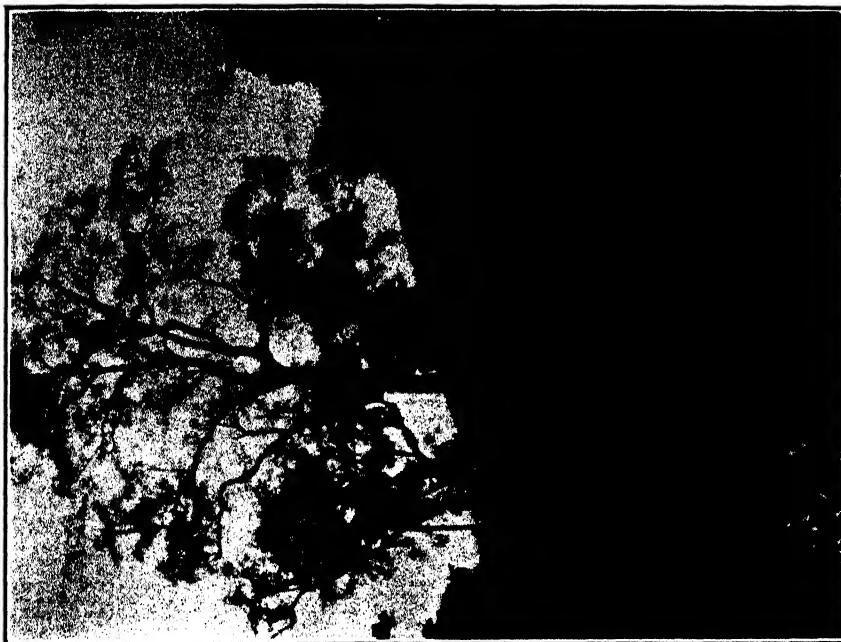
*Ficus minahassae*, Mt. Makiling, Philippine Islands.



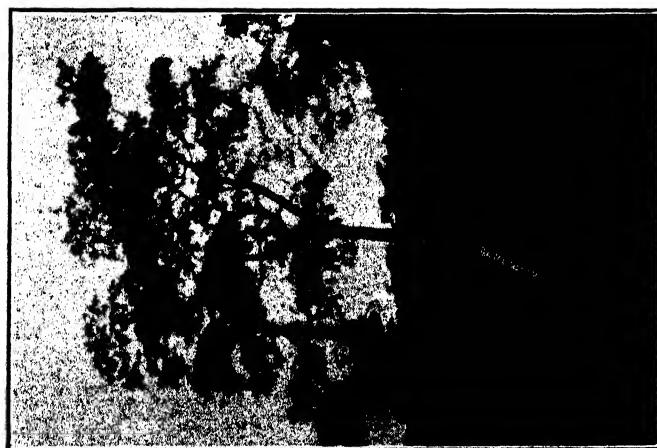
Mt. Makiling, Philippine Islands. Heavy forest extends to top.



*Parkia timoriana*, volunteer in cultivated land at base of Mt. Makiling, Philippine Islands.



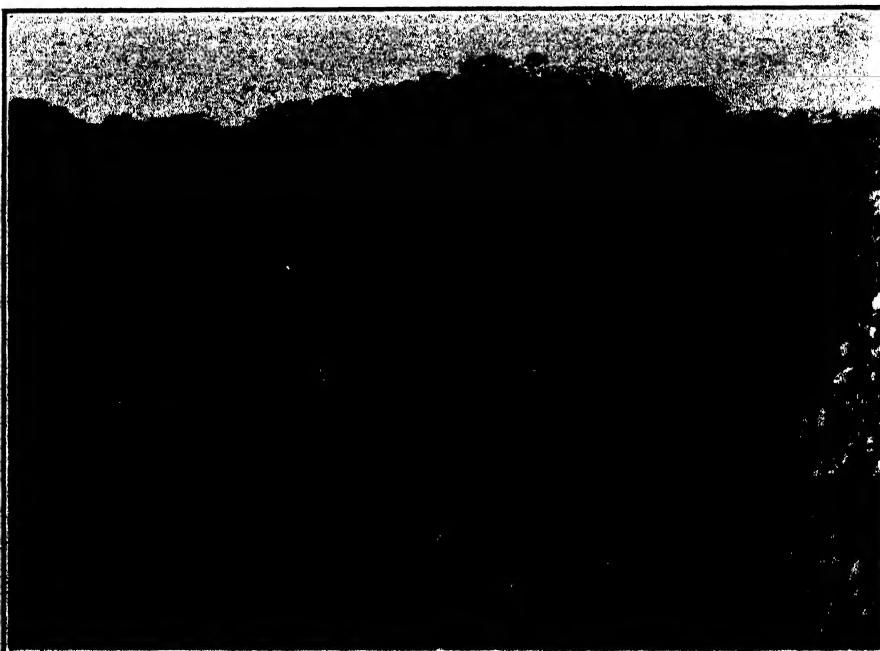
*Parkia timoriana*, at edge of forest, Mt. Makiling,  
Philippine Islands.



*Parkia timoriana*, at base of Mt. Makiling,  
Philippine Islands. Trunk 2½ feet  
in diameter.



Base of giant *Ficus sp.*, Mt. Makiling, Philippine Islands. Elevation 1500 feet.



General forest conditions, Mt. Makiling, Philippine Islands. Elevation 500 feet. Giant *Parkia timoriana* in foreground. Diameter of trunk is five feet.



Typical forest conditions, Mt. Makiling, Philippine Islands. Elevation 1500 feet.



Large *Ficus* sp., Mt. Makiling, Philippine Islands. Elevation 1500 feet.



Molawin River, Mt. Makiling, Philippine Islands.  
Elevation 300 feet.



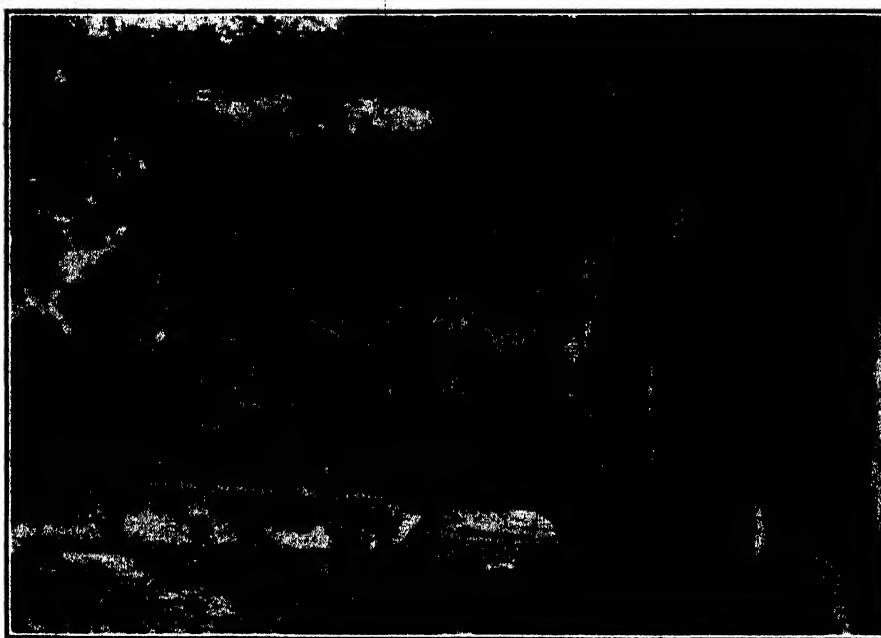
Typical forest conditions, Mt. Makiling, Philippine Islands. Elevation 2000 feet.



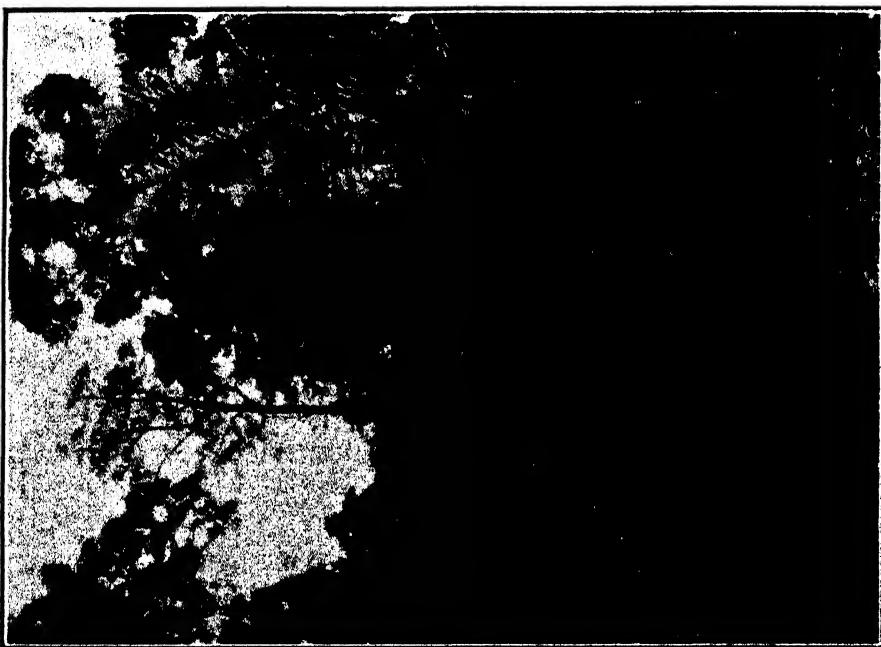
Typical forest conditions at 2500 feet elevation, Mt. Makiling, Philippine Islands.



Edge of forest, at base of Mt. Makiling, Philippine Islands.



Avenue of *Canarium commune*, Botanic Garden, Buitenzorg, Java.



Edge of forest, Mt. Makiling, Philippine Islands.



Buttressed trunk of *Ficus cordifolia*, Botanie Garden, Buitenzorg, Java.

## Losses From Mosaic Kohala Sugar Company, Experiment No. 1

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By J. A. VERRET

One of the better known Kohala seedlings is Kohala 202. This cane shows promise as a good producer for medium and mauka elevations.

Kohala 202 has one unfortunate weakness in that it takes mosaic rather readily.

So it was determined to test out the effect of mosaic on the yields of this variety. With the cooperation of the Kohala Sugar Company a test was laid out on that plantation. Four plots were used. Two of these plots were planted with carefully selected healthy seed, and two were planted with seed from mosaic plants. All the primary shoots from the diseased seed showed mosaic in early growth, while no mosaic was present in the healthy plots in the beginning, but at harvest it was found that several stools had become infected. On the other hand, several stools in the diseased plots were found free of mosaic. Apparently these stools had recovered from the earlier infection.

The cane was harvested in February, 1927, when the cane was 18 months old.

The results are given below:

### YIELDS

Plots	Area	Tons Cane	T. C. P. A.	Q. R.	T. S. P. A.
1—Mosaic .....	.0439 ac.	2.418	55.1	7.38	7.46
2—Healthy .....	.0459	2.654	57.8	7.02	8.23
3—Mosaic .....	.0444	2.386	53.7	7.38	7.27
4—Healthy .....	.0385	2.238	68.1	7.02	8.27
<hr/>					
Average Mosaic .....			54.4		7.34
Average Healthy .....			57.9		8.27
<hr/>					
Difference in favor of healthy....			3.5		.93

### JUICES

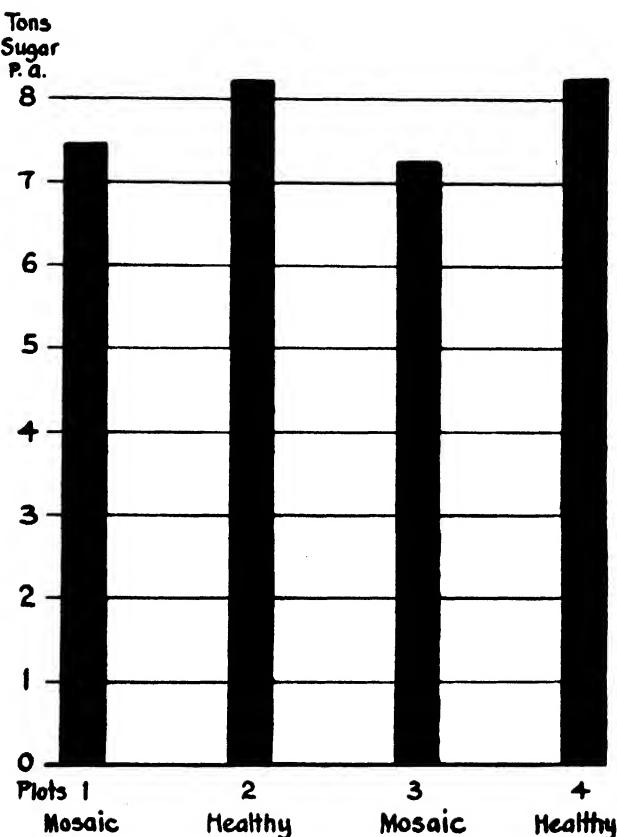
	Brix	Pol.	Purity	Q. R.
Mosaic .....	19.62	17.77	90.6	7.38
Normal .....	19.72	18.36	93.1	7.02

You will see from these results that the diseased seed plots produced 0.93 ton of sugar per acre less than did those planted with healthy seed. This is a loss of about 11 per cent when the field is approximately 100 per cent infected. Most of our other cane varieties would show larger losses than this with complete infection. K 202 is very tolerant of the disease, but on the other hand, as before remarked, it contracts the disease very readily and unless due care is exercised plantings of this variety would soon be heavily infected.

## HEALTHY VS. MOSAIC SEED

KOMALA 202

Kohala Sugar Co. Exp. I, 1927 Crop



The best methods of control for mosaic have been found to be the following:

1. Very careful inspection of all seed while cutting in order that only healthy seed be planted.
2. Roguing. This consists of periodic inspections of the field and the digging up of all diseased stools found. It is not necessary to burn or take away these destroyed stools. They do no harm when allowed to remain on the field.
3. Clean culture. Mosaic is transmitted by the corn aphid. This insect prefers many of the grasses to sugar cane and is more likely to be found in cane fields where grasses are than in clean ones. Many of these grasses get mosaic. This is the reason mosaic is more likely to be found along the edges of fields, along ditches and roads where grasses are growing.

## The Brown Australian Lacewing (*Micromus vinaceus*)

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BY FRANCIS X. WILLIAMS

The brown Australian lacewing was brought into the Hawaiian Islands in August, 1919, to help destroy the various plant-lice, particularly those affecting the sugar cane and corn plants. Though apparently a frail insect it readily became established and is now found, in suitable localities, on the four principal islands of the group. It has proved a useful if rather inconspicuous insect and is usually present wherever there are *aphis* infestations.

*Micromus vinaceus* belongs to the order Neuroptera, and to the family Hemerobiidae, or brown lacewings. As an adult it has quiet and probably nocturnal habits and a wing expanse of about a half inch. It is not, however, very bent on flying, and when at rest, with the wings held steeply roof-like over its back and the long beadlike feelers extended forward and close together, is not readily seen, the less so when on some dead leaf which it resembles in color. Often when disturbed it will fall over on its side and thus seek safety in playing possum.

During July, 1919, while working in the sugar cane district near the town of Halifax, on the Herbert River, North Queensland, Australia, the writer caged, among other beneficial insects, a number of this little lacewing with some of its *aphis* prey, and of these succeeded in bringing fourteen alive to Honolulu. From these few *Micromus*, thousands were reared through many generations, into the following year.\*

The eggs of *Micromus* are devoid of the long pedicels found in those of its relatives, the larger and frequently ill-smelling green lacewings (*Chrysopidae*); they are oblong cylindrical and deposited in groups along their long axis, one egg often touching another; they measure about  $\frac{3}{4} \times \frac{1}{3}$  millimeters and bear a small knob, the micropylar area, at the opaque end. The color is a sort of pale iridescent carneous. Viewed under high magnification the surface exhibits a design of fine network. Captive *Micromus* never oviposited on the glass sides of their prison, rarely on the green leaves of the sugar cane, but commonly upon cloth or cotton. A single mated female deposits a large number of eggs, but must be well fed to secure optimum results; in one case a specimen commenced laying on the third day after emerging from the cocoon and laid 558 eggs for her lifetime of thirty days, oviposition continuing until the day of her death; another specimen in her life of twenty-one days laid 619 eggs during eighteen days.

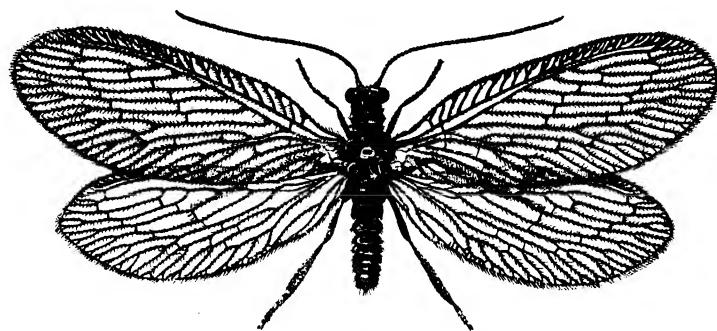
The eggs hatch in about three days, the larva making a more or less longitudinal slit at the micropylar end, and in crawling out regularly leaves the outer membrane or serosa that enveloped it within the shell, partly hanging from this slit. Freshly emerged, it measures nearly two millimeters long—having been curled up in the egg—and tapers fusiform from near the middle of the body to either

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\* P. H. Timberlake, formerly of this Experiment Station, did some of this breeding work.

end; the tail especially being slender; the thorax is furnished with three pairs of legs, and in addition, the posterior extremity of the body is also used leg-like, in aiding locomotion. The head is rather polished, darker at the sides, and bears slender feelers, mouth palps and a strong pair of rather curved and pointed mandibles and maxillae; the larger palps, the antennae and legs in part are smoky blackish; the color of the body as a whole is very pale brown, the intestine showing through as a darker shade; while there is evidence of creamy white markings on the thorax. In addition, there is a clothing of rather sparse dark hairs.

This, the first stage larva commences feeding very soon, and when in captivity and doubtless also when at large, does not hesitate to make a meal of an egg or two of an unfortunate brother or sister that failed to hatch so quickly. Piercing the delicate egg shell with the tips of its jaws it sucks the contents through the imperfect tube formed by the mouth parts, it pushes these a little deeper within, then withdraws them somewhat, or it may twist the head slightly from side to side; this sawing action probably assists in absorbing the content of the egg, the latter soon collapsing. More normally, this dragon-like creature wanders about seeking aphids and perhaps other small bugs, and mites.



The day following its birth (in the single case noted) it sheds its skin to become a second stage (or instar) larva; it first glues its tail fast to some object and when ready for the moult pulls itself out of the loosened skin. It is now about four millimeters long, with the markings more pronounced and extended than in the first stage. After further eating, its skin again becomes too tight for it and the second moult takes place, in the case tabulated, on the day following the first moult. Such a last stage larva a few hours old is about six millimeters in length and marked as follows: the tips of the antennae are whitish, the legs from their origin to the base of the tibial part and the extremity of the tarsi are blackish; the body in general is of a dull purplish color, blackish in the middle and at the tail end, the first part of the thorax with a pinkish white stripe at the sides, and the latter half of the third segment of the thorax has a split band of whitish color on the back, while the last five abdominal segments but one bear a broken stripe of this color along the sides, but showing also, though more faintly, on the back where it is divided by the dark line of the dorsal blood vessel.

In its four days or so of active life as a larva, *Micromus* feeds voraciously. Unlike the larva of certain green lacewings it does not adorn its body with a protective covering of the skins of its dry-sucked victims, but runs about naked and comparatively defenseless, and we must attribute its success in the struggle for existence, in great measure, to the large number of eggs laid, over a relatively long period, by a single female. As observed in captivity one larva will readily devour another of its kind and occasionally we see a specimen whose curtailed posterior extremity would indicate bare escape from the jaws of one of its hungry fellows. A larva on the move sways the head from side to side in jerky fashion and feels its way or, its food, by means of the downward-pointing palpi; when it encounters another *Micromus* larva, it will often jab or peck at it with open jaws, the offended relative retaliating with blows from its tail; sometimes two will unwillingly share an aphis but one will eventually pull the morsel away from the other. When an aphis is encountered it may or may not be seized immediately, *Micromus* will palp it perhaps, or make cautious digs at it with open mandibles sometimes thus piercing it; the homopteron thus apprised of its peril becomes very agitated; it may beat a retreat or sway its uplifted abdomen and exude a darkish liquid from the tubular processes near the end of the body. After such and additional preliminaries, *Micromus* deeply stabs its victim, commences sucking immediately and bracing itself pulls its prey off the leaf and raising it aloft soon converts the unfortunate bug into a collapsed sack. While thus feeding, the antennae and palps are held clear of the aphis.

With plenty of food available the Hemerobiid attains full growth within two days of its second moult and now chooses a place, such as the concavity of a leaf surface in which to spin the delicate mesh-like cocoon. Silk-producing apparatus in by far the greater number of insects consist of glands that unite as a common duct opening at the mouth parts. Such are the spinning glands of the silkworm of commerce and of other moth caterpillars. A notable exception in the location of such organs is to be found in the family Embiidae, composed of a relatively small and rare group of termite-like insects that spin a web with their fore paws, the gland ducts in this case opening through hollow bristles. And perhaps an equally strange allocation of silk glands occurs in the larva of the brown lacewing and in many other more or less closely related neuropterous insects, for here a portion of the Malpighian tubes (comparable in general function to the kidneys of vertebrates) becomes modified into silk glands, so that the insect employs its tail as a spinner. Two transverse parallel silken sheets are formed some millimeters apart and between which the oblong spindle-shaped cocoon proper is spun; it is quite fragile—merely an open meshwoork of pale silk with little dew-like thickenings along the strands—and conceals but slightly the larva or later, the pupa. The length of the cocoon proper is about five millimeters. It now encloses a larva that in preparing to form a pupa assumes a pupa-like pose, lying quietly with its head bowed down, its legs over the breast and its posterior extremity curved forward rather hook-like; in this unextended posture it measures about 3.75 millimeters long. In due time this, the third larval skin, is discarded, and lies shrivelled

near the end of the freshly formed pupa. The pupa is carneous and whitish in color, except for the glassy, milky transparent appendages, the eyes and tips of the mandibles being dark, and it rests, thinly clad in long pale hairs, in a huddled pose, the appendages, however, being freely moveable. It is fairly active when disturbed and yet more so at the last, for it then bites its way out of the delicate network, crawls on top of the cocoon or beyond it, the skin splits along the back of the thorax and the adult *Micromus* is disclosed. Soon its wings attain their proper length and strengthen with the rest of the body so that in a few minutes it is fully mature.

The entire life-cycle—from the laying of the eggs until the hatching of the adult—may not occupy more than two weeks, so that under favorable conditions the insect multiplies rapidly. The adults are very quiet in captivity and themselves devour a great quantity of aphids; in one case, the female of a freshly emerged pair ate fifteen aphids in ten minutes, her mate consuming thirteen in seven and one-half minutes. They were observed to wash or brush their faces with the forepaws.

The brown lacewing was reared in the laboratory in Honolulu for a full year after its introduction from Australia, the first adults being liberated at the Waipio substation, Oahu, on September 17, 1919, while the last lot, which included the seventeenth generation, was released on the H. S. P. A. Experiment Station grounds on August 27, 1920. Records show that approximately 5,200 adult *Micromus*, besides a quantity of eggs, were distributed in the cane fields of Kauai, Oahu, Maui and Hawaii, and where they were later recovered.

## Further Notes on Stem Galls of the Sugar Cane

By H. L. LYON

In a paper published in *The Hawaiian Planters' Record* for October, 1926, the writer described a disease of the sugar cane, the one striking symptom of which was the appearance of overgrowths or galls on the stem. It was pointed out that this disease had been known to occur sporadically in the cane fields of these Islands since 1910, but that it had not assumed alarming characters until 1925, when it appeared in epidemic form in the canes on the Makiki Plots of this Experiment Station.

In the paper referred to, we list 74 varieties of cane on which galls had been found at the Experiment Station. A few of these canes were dug out and destroyed during the late months of 1926, but the majority were carried through into 1927. Seventeen additional canes in the 25 Q series, numbers 1, 7, 11, 18, 27, 70, 75, 119, 124, 150, 156, 158, 159, 162, 167, 188, 214, developed galls before they were cut in 1927. Galls also appeared on several plants of U. D. 1.

During the early months of 1926, 3,467 seedling canes from the 1926 sowings were planted out at the Makiki Plots. During the early months of the present

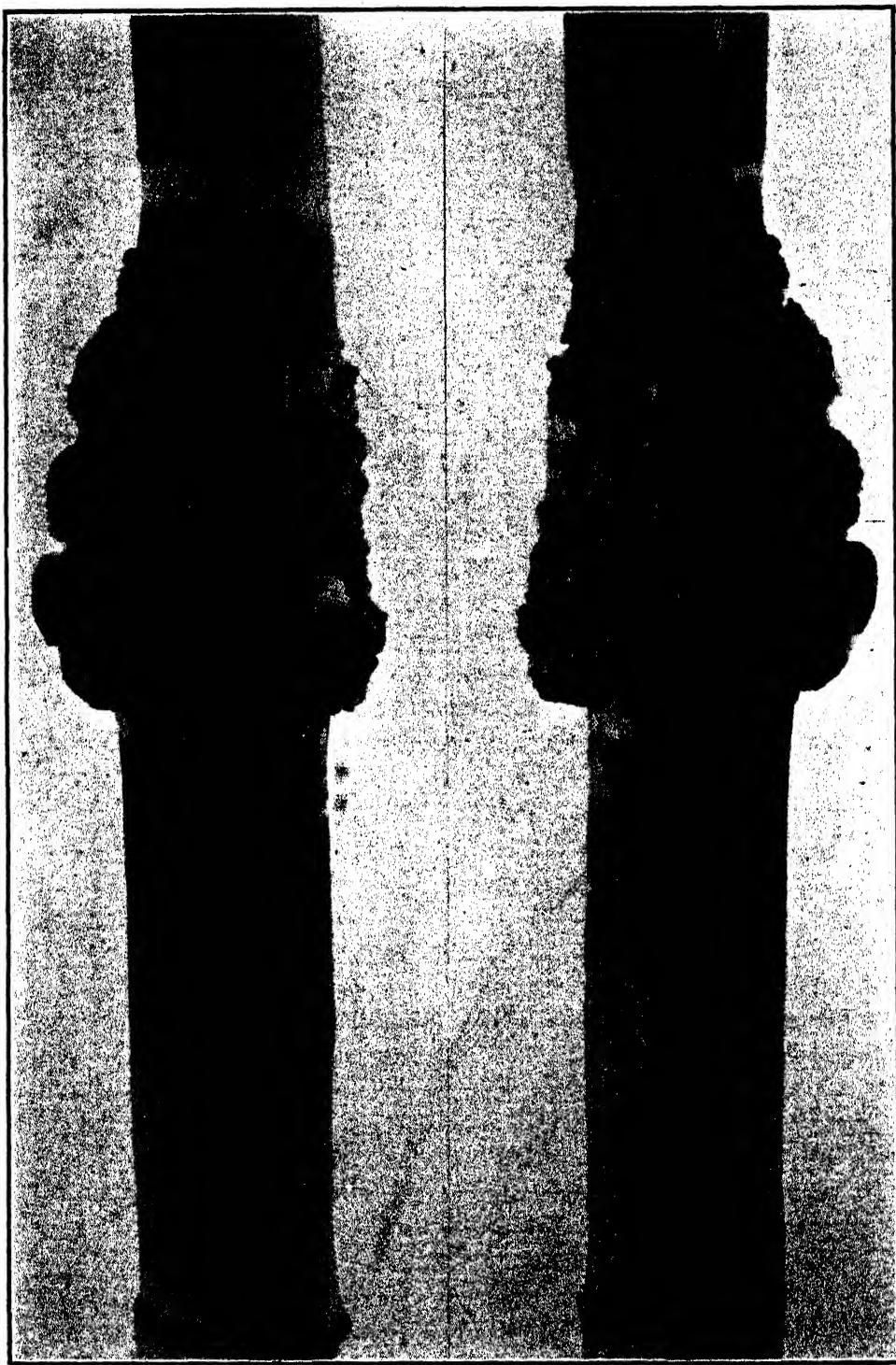


Fig. 1. Stem galls on 25-Q-27. Two views of the same internode. Photo by Twigg Smith.

year, these seedlings were subjected to a first selection for the isolation of the promising varieties. Two plots carrying 728 seedlings were cleared without any data on the occurrence of galls being recorded and, in some of the other plots, many of the poorer seedlings were eliminated before note was taken of the presence or absence of galls on their sticks. When a survey was made of the seedlings still standing, galls were found on 312. The exact number of seedlings examined was not recorded, but it was most certainly less than 2,739, so we know that at least one out of every nine of these 1926 seedlings contracted the gall disease during its first year's growth. It is obvious that the epidemic of 1926 carried over into 1927 with an ever-increasing momentum.

About the first of the year, galls of large size were found to occur in abundance on sticks of U. D. 1 growing in the recently developed experimental plot on lands belonging to the Mid-Pacific Institute. An examination of all of the canes made by Messrs. Das and Jain showed that the disease had appeared on many of the other varieties and on some in a very aggravated form. There were 32 U. D. varieties planted in this field, and galls occurred on 16 of them, among the latter being the 8 varieties named hereafter which were not included among the diseased canes listed in our former paper: Numbers 1, 9, 10, 17, 26, 85, 97, and 104. In a small block of D 1135, 42 per cent of the stools showed galls. Sticks bearing galls were also found in the plantings of Badila, Striped Mexican and P. O. J. 979. The Tip cane in its varieties, Striped and Yellow, occupied more space in the field than any other cane and, in fact, stools were growing next to those of every other variety; yet, not a single specimen bearing galls could be found although they were most diligently sought after. Likewise, no symptoms of the disease were detected in H 109, Lahaina, Yellow Caledonia, Uba, H 8965, H 89102 and U. D. 110, each of which occupied relatively large blocks. The disease was also absent in small blocks of P. O. J. 36, P. O. J. 213, P. O. J. 234, Manoa 300 and U. H. 1.

From the above survey, it will be seen that galls were found on sticks of 20 of the 49 cane varieties planted in the Mid-Pacific Plot. The prevalence of the disease in this plot and the aggravated form which it took on some varieties—notably U. D. 1, U. D. 13, and U. D. 25—caused much concern and, in February, 1927, the plot was declared quarantined and no canes have since been removed from this area for planting elsewhere.

Mr. Das reports the finding of galls on sticks of 20 different varieties of the U. D. series growing at the Manoa substation. Number 1 is included in his list, as are also numbers 16, 41, and 59, which have not been reported as diseased in other plantings.

Galls have been found on several occasions at Waipio, but, according to our information, they did not occur in an aggravated form in any case. Galls were detected for the first time on U. D. 58 at this substation.

At the Pathology Plot on the corner of Alexander and Bingham Streets in Honolulu, large galls were found by Mr. Muir on two stalks of H 109 growing from a cutting which had been planted seven months previous. These galls were well below the surface of the ground and were only discovered after the stool had been

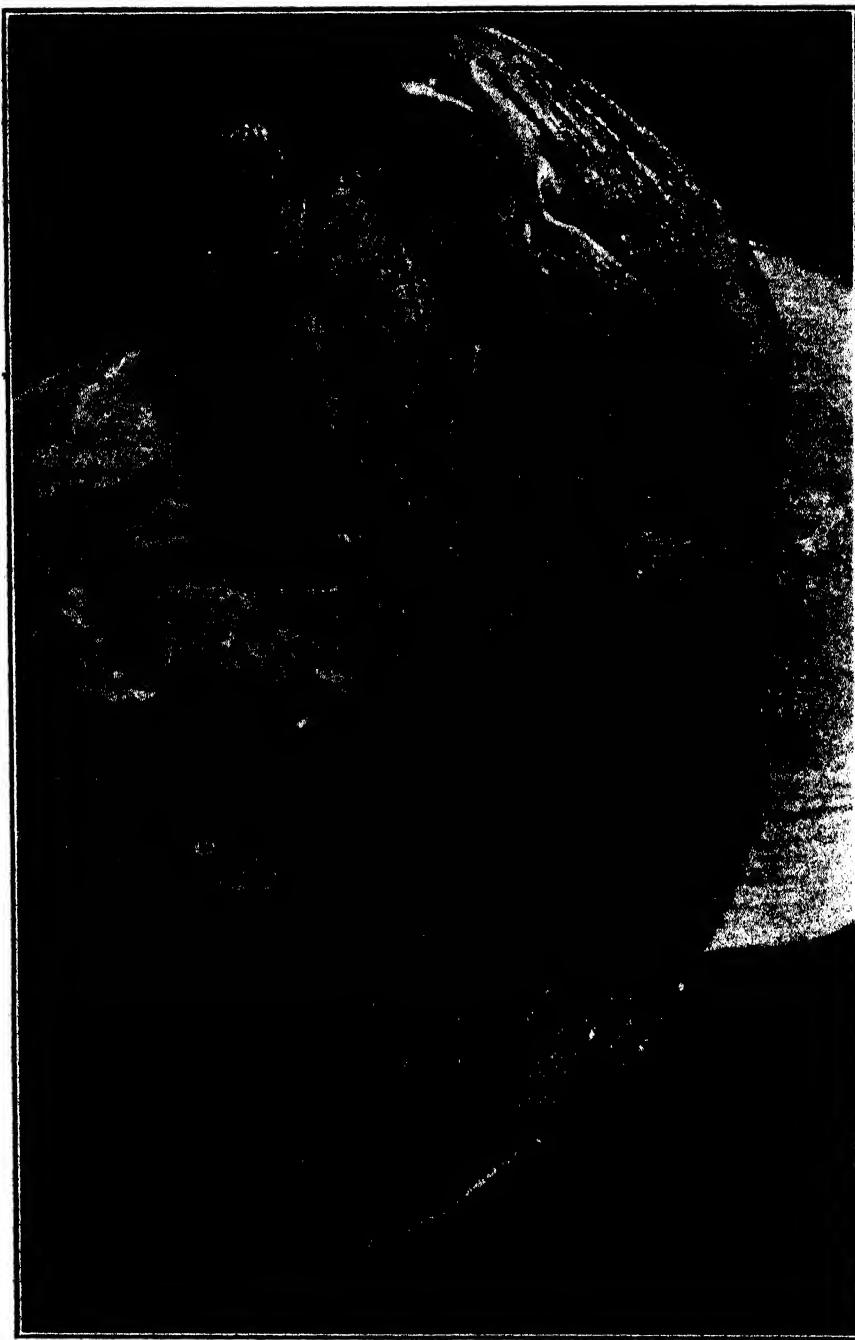


Fig. 2. Foloids or wing galls on U. D. 13. Enlarged about 8 diameters. Photo by Twigg Smith.

dug out for the purpose of examining its roots for the occurrence of nematodes. A careful search revealed no galls at any other point on the several sticks in this stool.

From several plantations, we have reports recording the appearance of galls in fields of U. D. 1, Makaweli 1, H 109, and D 1135. Galls have also been detected on several plantations in experimental plantings of canes belonging to the U. D. and 25 Q series.

At Grove Farm, on Kauai, galls were noted for the first time on five canes of the 25 Q series as follows: Numbers 16, 23, 89, 128, and 151.

The outline as given above of the occurrence and distribution of this gall disease on our sugar cane is, by no means, exhaustive, but it should serve to indicate that the disease is becoming widely distributed in these Islands.

#### GALLS AND KNIFE-CUT

Our observations have demonstrated beyond a doubt that the production of transverse cracks in the stem may be induced by the gall disease. (See Figs. 3 and 4.) This particular type of lesion has been previously noted in cane literature under the term "knife-cut," but it has not been considered a symptom of the gall disease. The term "knife-cut" is quite descriptive of the lesion, for it looks as though a transverse incision had been made in the stem with some sharp instrument after which the cut edges pull apart, leaving a gaping wound. Knife-cut accompanies gall production in many varieties of cane, but is much more exaggerated in some than in others. In some varieties, the incisions are never long, extending at most not over a quarter of the way around the stem. In other varieties, the knife-cuts will be numerous and deep, commonly extending a third to a half way around the stalk and occasionally one may be found completely girdling the stalk.

These extensive and deep knife-cuts greatly weaken the stems and the stalks so afflicted frequently break off through the knife-cut. Several of our seedling varieties of cane, upon contracting gall disease, showed the knife-cut lesions in great numbers and in exaggerated forms. The seedling 25-Q-88 was very badly afflicted with galls and also showed knife-cut at frequent intervals throughout the length of its sticks. In a very large stool of this variety growing in the interior of a block of cane, we counted twenty-two sticks which had broken square off 2 to 4 feet above the ground, each stick breaking through a knife-cut.

#### GALLS AND BUNCH-TOP

In our former paper, we stated that bunch-top is quite often associated with the stem gall disease and we offered the opinion that it was due to the same causal factor. Competent observers here in Hawaii have expressed some doubt as to the soundness of this conclusion and it has also been questioned by Mr. D. S. North of Australia, as may be learned from his letter which we shall quote further on in the present paper.

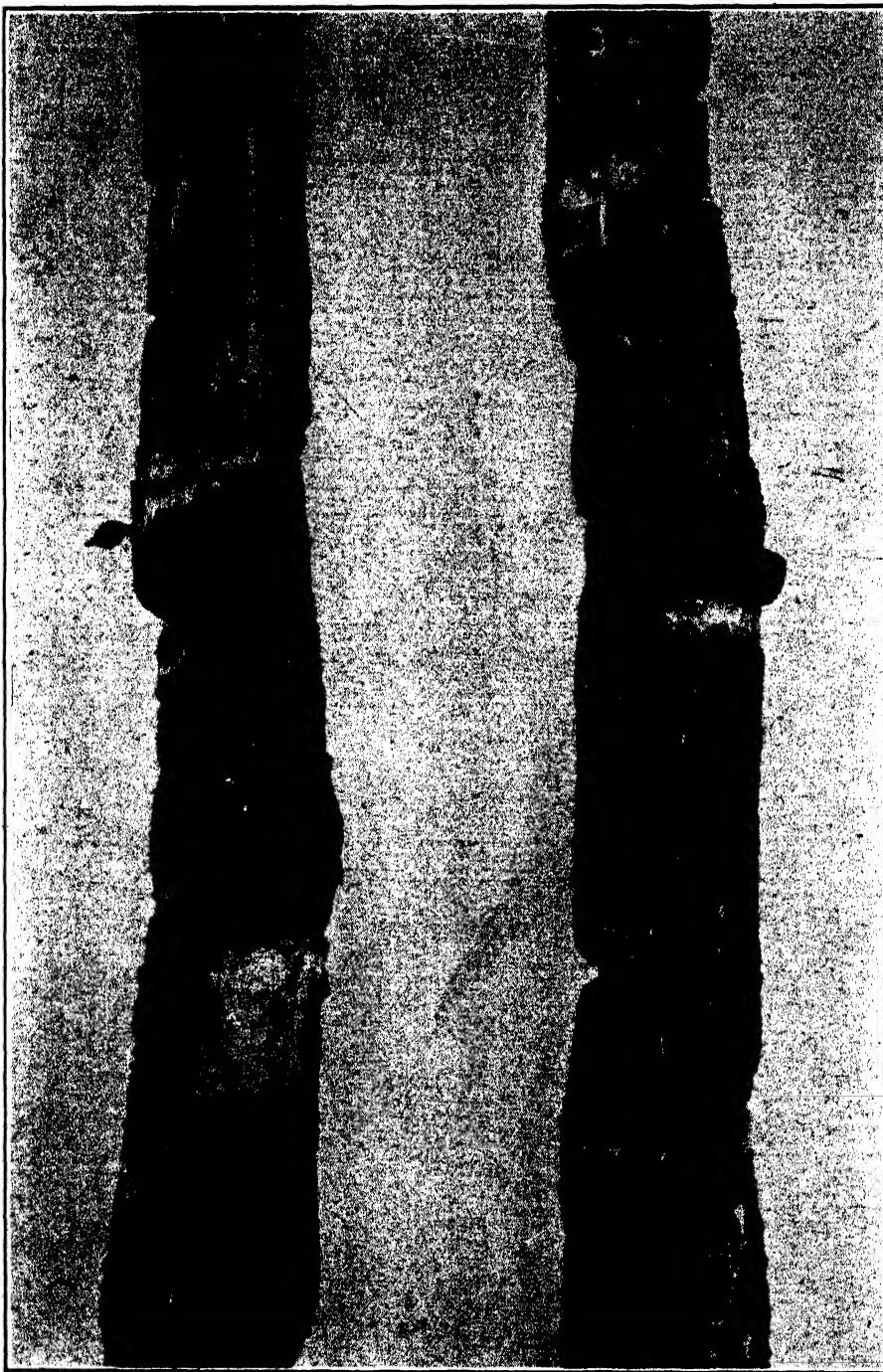


Fig. 3. Galls and knife-cut on sticks of 25-Q-137. The galls are most numerous on the internodes, and the knife-cut lesions are confined to these regions. Photo by E. L. Caum.

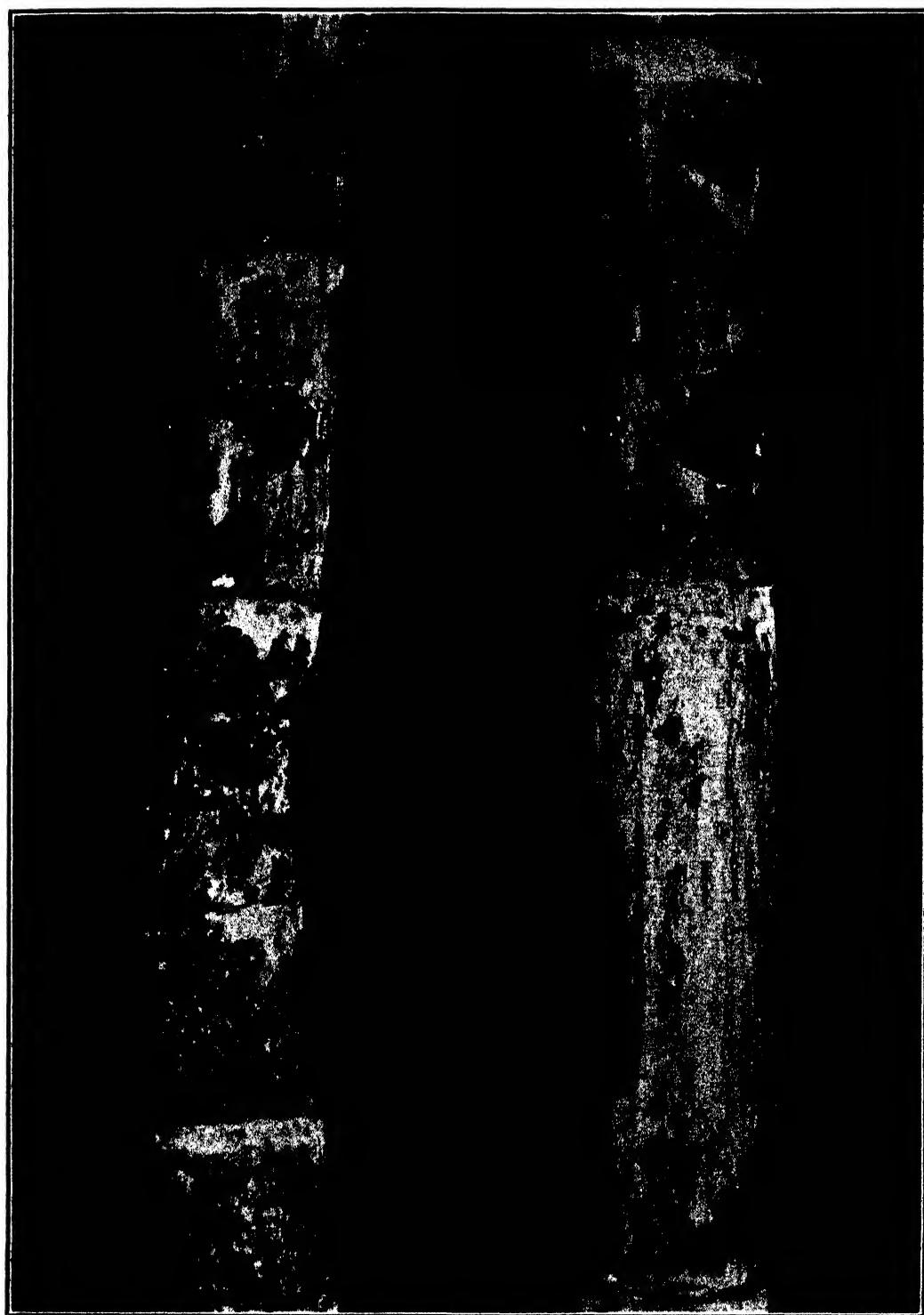


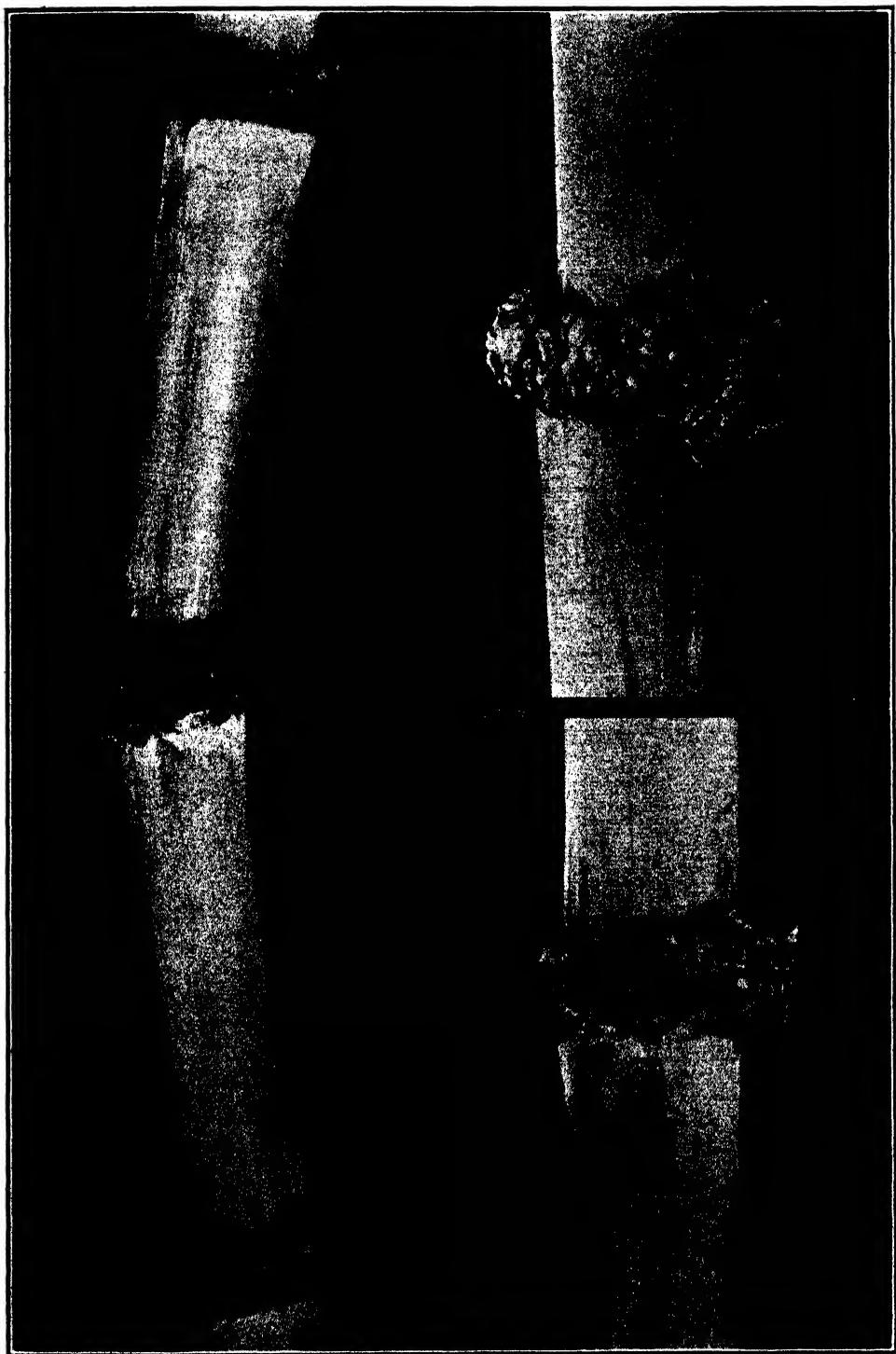
Fig. 4. Additional examples of galls and knife-cuts on 25-Q-137. Photo by Twigg Smith.

During April of this year, the manager of the Hawaiian Commercial and Sugar Company called our attention to the fact that bunch-top was very prevalent in certain fields of H 109 at Puunene. A careful examination of many of the sticks bearing this bunch-top showed that they did not carry galls at any other point throughout their entire length. Frank Broadbent, who accompanied us in the field, expressed adherence to our former conclusion that "bunch-top is a mal-growth resulting through the abortion of an inflorescence or tassel." The specimens examined by us in the field offered strong evidence in support of this view, for in every case, seven or eight nodes below the bunch-top did not bear any eyes. It is a well known fact that sticks of many varieties of cane always stop producing eyes on their nodes for a short time before they shoot up the tassel. It is quite possible that bunch-top is, in many cases, an aborted tassel, but the question remains, what causes the tassel to abort and become transformed into this particular type of gall. As bunch-top occurs very freely in canes afflicted by the gall disease, it seems reasonable to at least suspect that it may be induced by the same cause. While this problem cannot be solved at the present time, still its ultimate solution is of considerable interest and importance. If bunch-top is a symptom of the gall disease, we can speak with more assurance regarding the history of the gall disease in Hawaii, for authentic cases of bunch-top were recorded in these Islands several years previous to the known appearance of typical stem galls on our canes.

#### GALLS AND CANE VARIETIES

The reactions of various varieties of cane to this gall disease are strikingly different. In fact, it is possible to identify many of the varieties by the type of gall which they produce and the distribution of these galls upon their stalks. U. D. 30 produces a mass of gall tissue which arises almost entirely from the root band. This gall tissue often forms a corrugated collar entirely encircling the node, as shown in Fig. 5. We have never found any galls on internodes of this variety. The variety 25-Q-137 suffers very seriously from the gall disease, but the galls are far more numerous on the internodes than they are on the nodes. In fact, a root band is often found quite free from galls when the internode directly above it is covered with a mass of galls. Although 25-Q-137 produces galls as freely as any variety yet examined, we have never, as yet, found an adventitious bud arising from its galls. All of its galled sticks—and these were all of its sticks in our cultures—showed numerous knife-cuts (see Figs. 3 and 4). It was early evident that this variety was rendered worthless by the gall disease and it was among the canes eliminated from our cultures at Makiki in 1926.

Some remarkable instances of localization of gall tissue are displayed by the varieties 26-Q-3127 and 26-Q-3214, which are illustrated in Figs. 6 and 7. In both of these varieties, gall tissue was produced in abundance, but only around the base of the lalas. The seedling 26-Q-2673, illustrated in Figs. 8 and 9, showed an interesting condition in that it produced large nodular (raspberry) galls on its internodes. The fact that it produced nearly spherical galls instead of the more common flattened ones found on most varieties is possibly due to the fact that it



**Fig. 5.** Galls on U. D. 30. In this variety the adventitious growths are confined to the nodal regions. Photos by Twigg Smith.



Fig. 6. Tumor at the base of a lala in 26-Q-3127, somewhat enlarged. Photo by E. L. Caum.

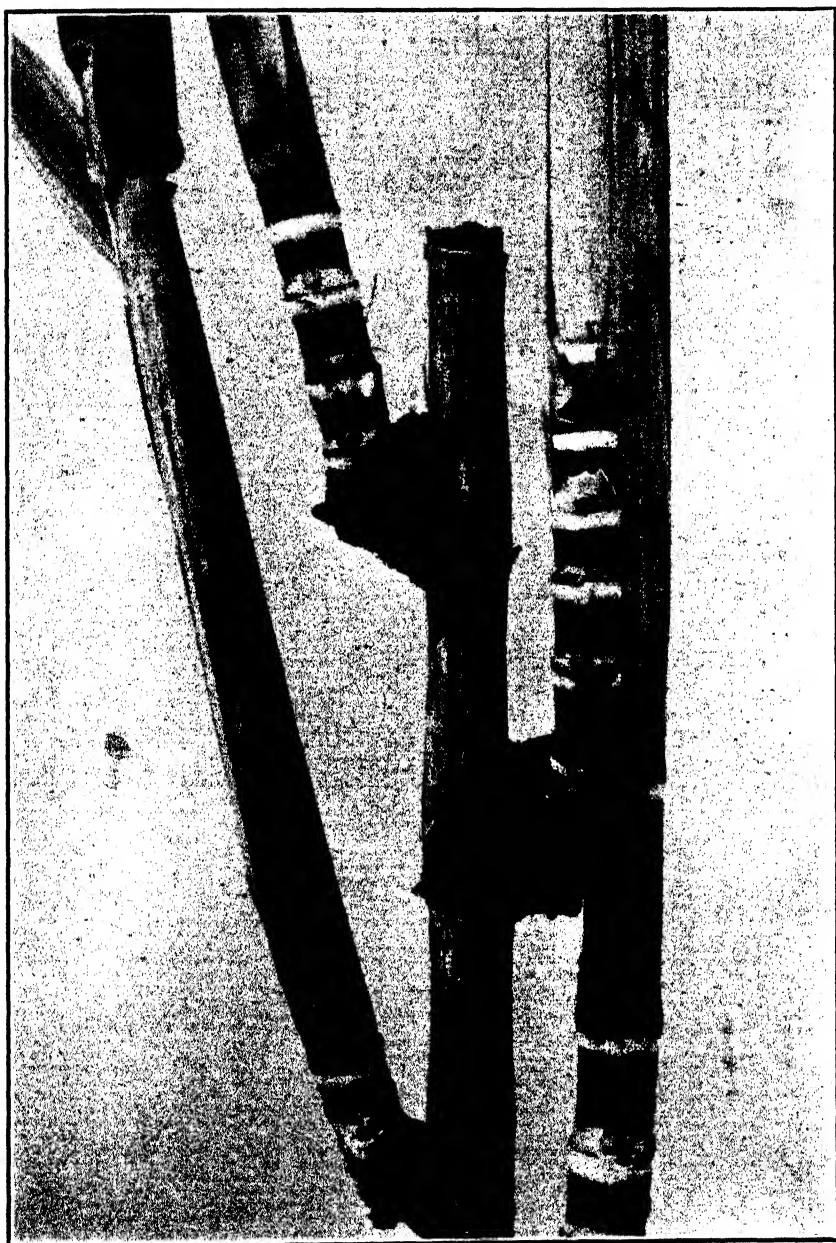


Fig. 7. Tumors about articulations between lalas and stalk in 26-Q-3214. Photo by E. L. Caum.

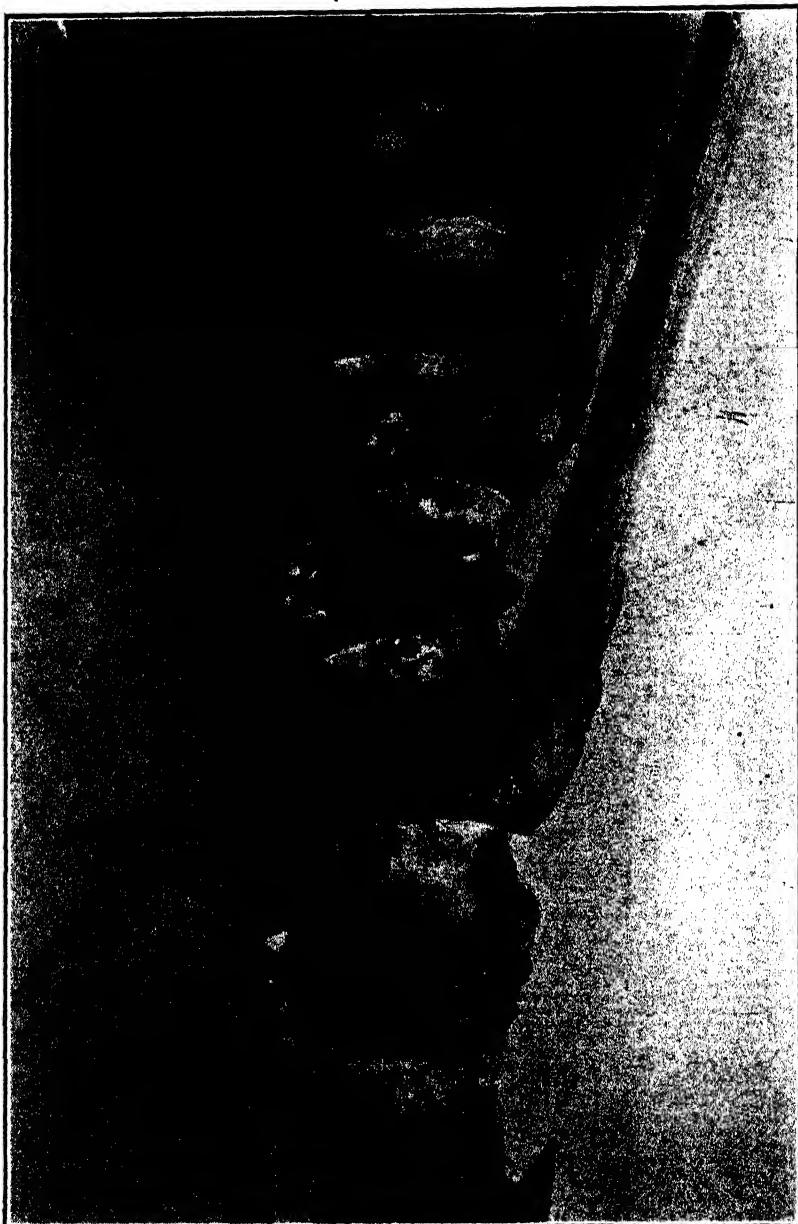


Fig. 8. Nodular or raspberry galls on a stick of 26-Q-2673. Photo by E. L. Caum.

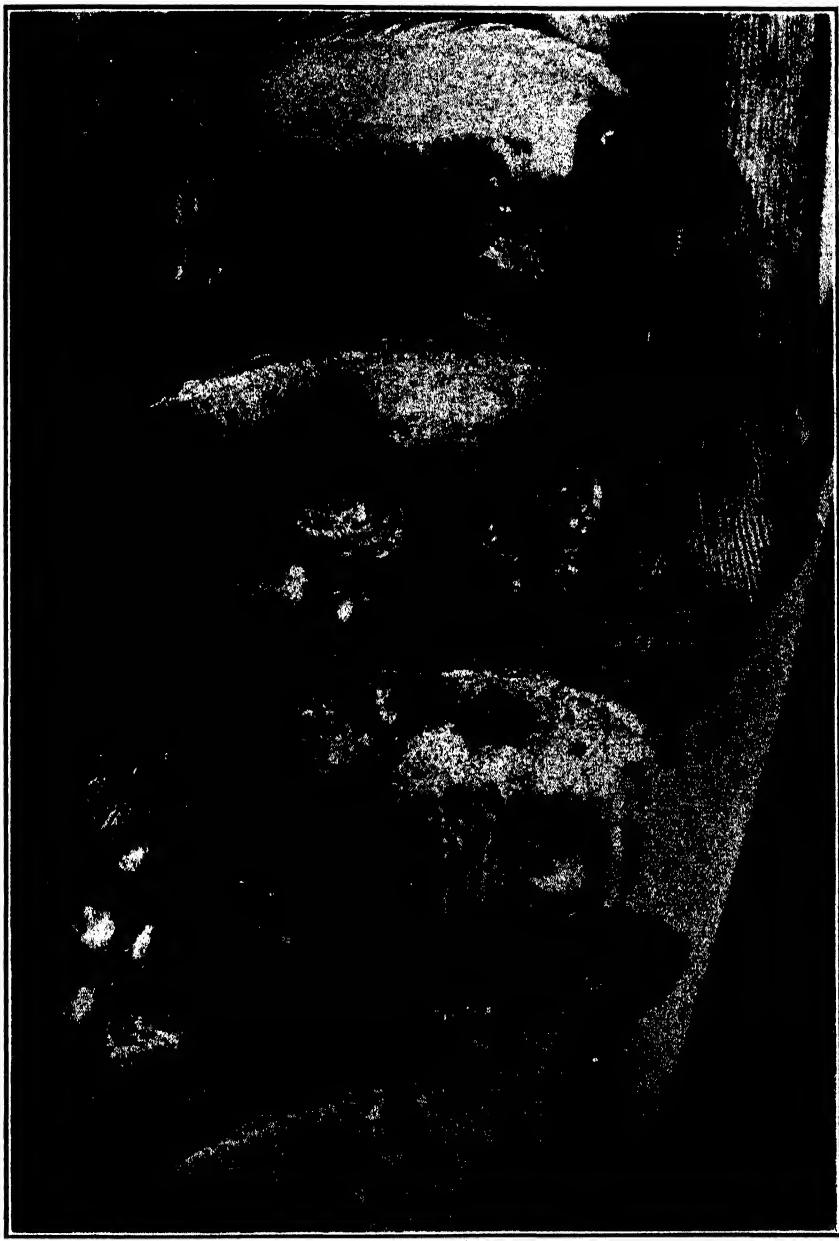


Fig. 9. A portion of the stick shown in Fig. 8, somewhat enlarged.  
Photo by E. L. Caum.

produced lalas very freely and these forced out the leaf sheaths at an early stage in the growth of the stick, thus relieving the gall tissue somewhat from the pressure of a closely adhering leaf sheath.

The imported cane P. O. J. 979, growing at the Mid-Pacific Plot, has also developed typical raspberry galls. In most cases observed, these galls occur on one or both sides of a normal eye, as shown in Fig. 10. As can be seen from this picture, they arise from node tissue.

Seedling U. D. 47, which supplied most of the illustrations of stem galls used in our former paper, has been grown in quarantine with the idea of seeing what will eventually happen to this variety as a result of the disease. We have had no difficulty in keeping this cane alive, but every stalk shows galls and many sticks are a veritable mass of galls throughout their entire length. The galls on this variety produce adventitious buds very freely and single joints often bear as many as twenty-five lateral shoots. The development of numerous long, thin galls on a leaf base, as shown in Fig. 11, is not uncommon in this variety. A few cases of galls on leaf bases have been noted in other cane varieties, but up to the present time, galls of the type with which we are now concerned have never been found on the blade of a cane leaf.

Because of the remarkable showing which U. D. 1 has made in field trials in several localities, the reactions of this variety to the gall disease are of special interest.

Galls were noted on U. D. 1 in 1925 and 1926, but they were never so numerous or of such an aggravated nature as to arouse much concern for the future of this variety. Early in 1927, however, it was discovered that the U. D. 1, growing in the Mid-Pacific Plot was heavily infested with galls and that in many cases, these galls took the form of very large tumors developing at, or just below, the surface of the ground. (See Fig. 12.) The sticks bearing these underground tumors were easily broken off by a fracture through the tumor. A careful survey of the U. D. 1, growing in the Mid-Pacific Plot, made by Messrs. Das and Jain, showed that out of a total of 188 stools of this variety only three were apparently free from galls and these three stools were composed of young shoots only, and consequently had not yet reached a stage where galls might be expected to show. Sticks of U. D. 1 often show an extensive development of galls on their aerial portions, as shown in Figs. 13 and 14. These galls appear on both nodes and internodes and are mostly of the folioid or winged type. That rank, succulent growth favors the production of galls is well illustrated in a large block of U. D. 1 in the Mid-Pacific Plot. The canes in certain rows in this plot were fertilized and irrigated, while the canes in alternating rows were neither fertilized nor irrigated. The favored canes are large and succulent and bear many galls, while the canes in the check plots are stunted, their sticks hard with the galls arrested at an early stage in their development.

The nine stools of U. D. 13 in the Mid-Pacific Plot all show galls in great abundance. The sticks of U. D. 25 have produced large underground galls which proliferate very freely, converting the stool into a compact mass of closely set shoots.

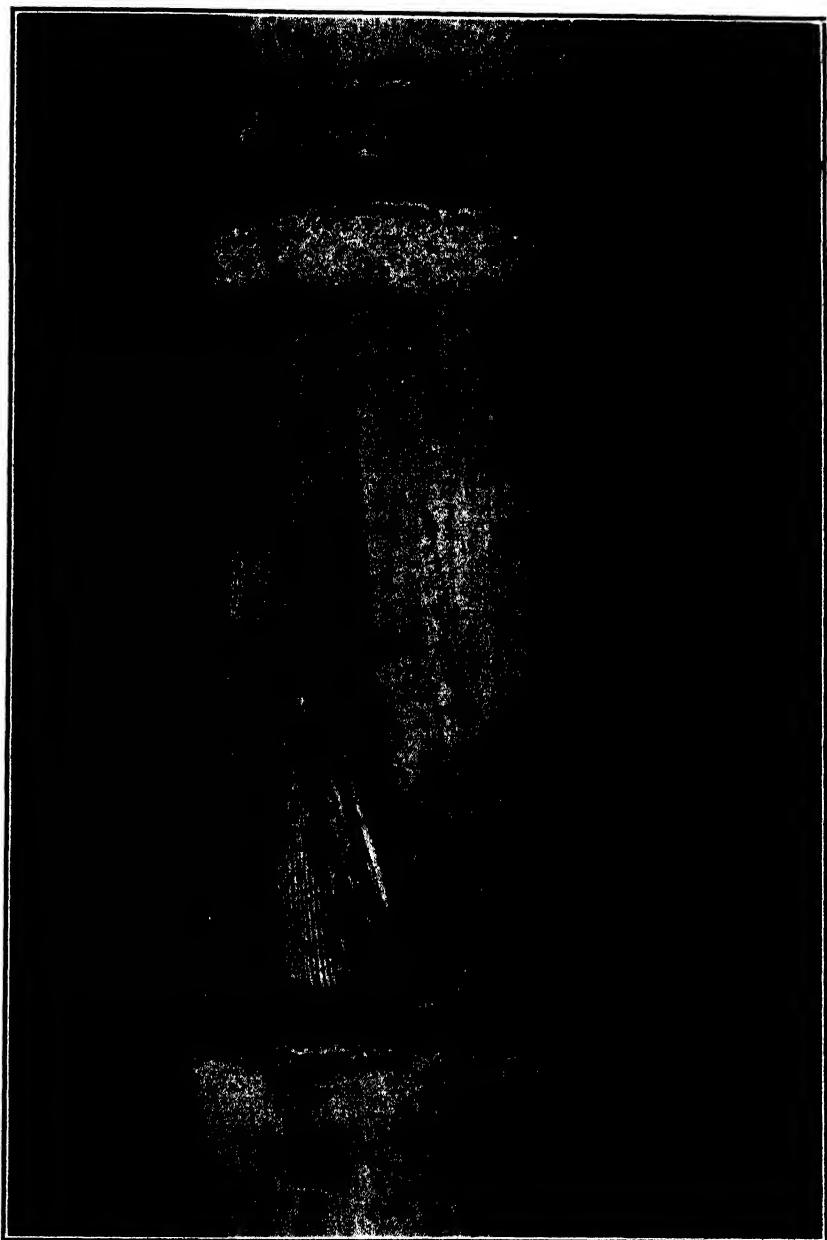


Fig. 10. Nodular or raspberry galls on a stick of P. O. J. 979. Photo by Twigg Smith.

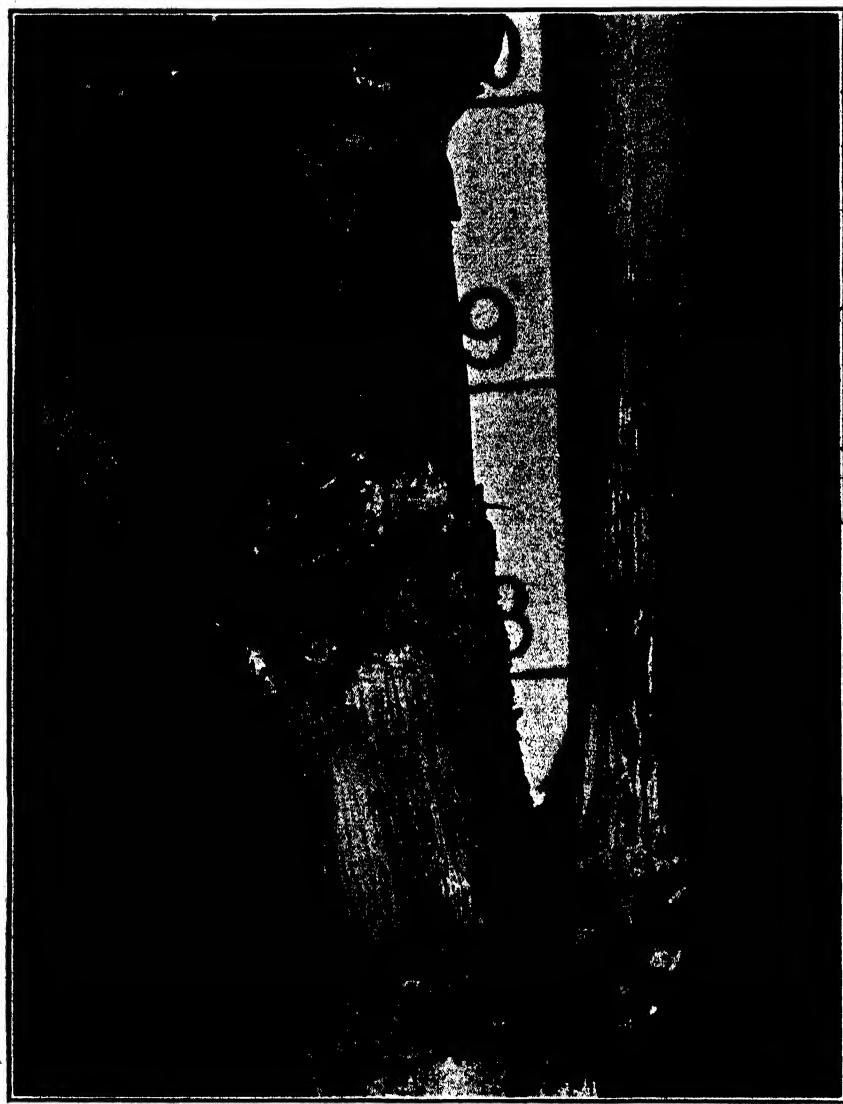


Fig. 11. Galls on the leaf sheath of a lala of U. D. 47. Photo by Twigg Smith.

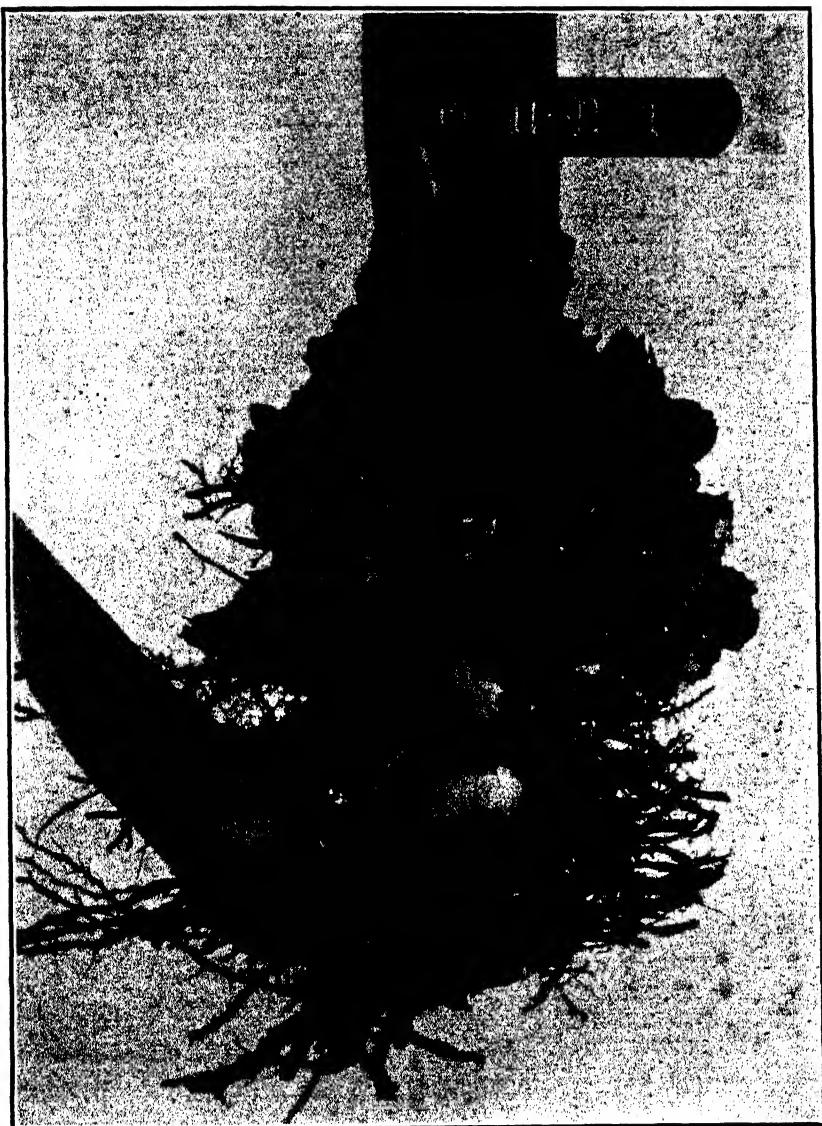


Fig. 12. Large tumor at the base of a stick of U. D. 1. Photo by E. L. Caum.



Fig. 13. Galls on sticks of U. D. 1. Photo by Twigg Smith.

It is becoming quite evident that D 1135 is susceptible to the gall disease, but carries it without displaying conspicuous symptoms. In February of the present year, Mr. Muir asked our opinion on a couple of specimens of D 1135 cane, which had been sent to him from Kauai by R. H. Van Zwaluwenburg. Mr. Van Zwaluwenburg reported that his attention had been called to this cane by the manager of Grove Farm, who had observed that many apparently healthy sticks of this variety were breaking off near the ground for no apparent reason. An examination of the specimens sent in by Mr. Van Zwaluwenburg showed that the sticks had broken off through a knife-cut. The writer suspected that this knife-cut was associated with gall production and made a trip to Kauai to investigate the matter. Broken down sticks were found in considerable numbers in certain areas and in all cases examined, the breaks were through knife-cuts, which occurred within a few inches of the surface of the ground. Typical galls were found on many of the sticks bearing knife-cut lesions. These galls were usually most numerous on the same internode with the knife-cut and often involved the same tissue. The galls were, in all cases, quite small, being arrested at a very early stage in their development. It is evident that the tissue of D 1135 strongly resists the influence which induces gall production. A curious, anomalous growth which we noted on sticks of D 1135 showing knife-cut was the occurrence of roots arising from the internode a short distance above an eye. These roots always took their origin in the eye groove and usually occurred at the apex of the groove, just a short distance below the wax band. In most cases, they were all hard, horny

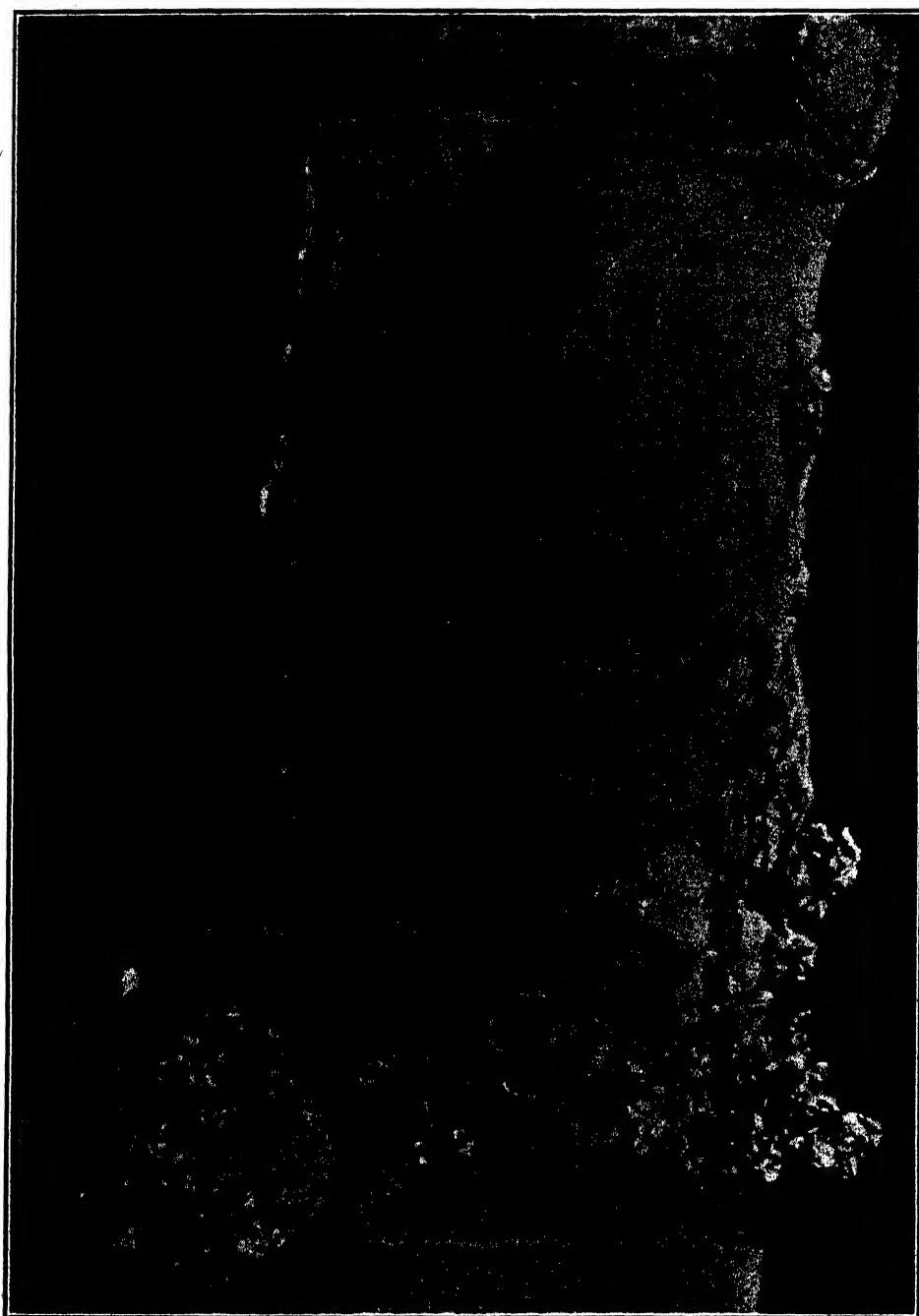


Fig. 14. Enlarged view of a section from one of the sticks of U. D. 1 shown in Fig. 13. Photo by Twigg Smith.

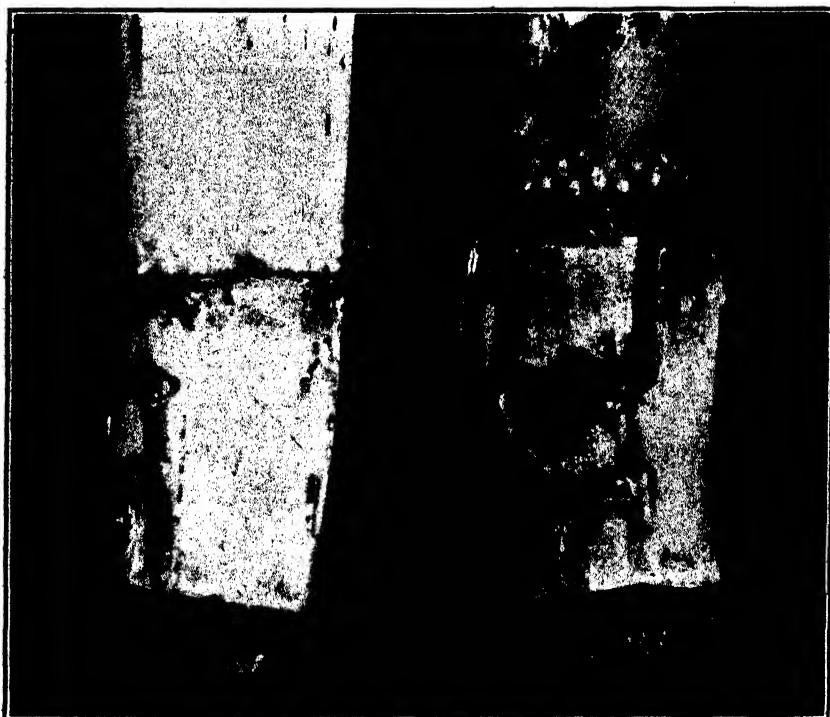


Fig. 15. Sticks of D 1135 from Grove Farm Plantation which broke off through knife-cut lesions. Both sticks showed adventitious roots and numerous small galls on the internode in which the knife-cut occurred.

protuberances, not over an eighth of an inch high, but several specimens were found in which the roots had grown to a length of 1 to 2 inches, but were much flattened, being closely appressed to the stem by the overlying leaf sheath. One case was found, however, where two such roots had become functional, producing numerous lateral roots. This case is illustrated in Fig. 16. Knife-cut, galls and internodal roots were found on D 1135 at Grove Farm only near the bases of cane shoots. Not a single example of any of these abnormalities was found to occur as much as a foot above the surface of the soil.

#### GALLS ON CANES IN OTHER COUNTRIES

In our former paper, we noted that galls of the type now appearing on our canes here in Hawaii, were recorded as occurring on canes in Java as long ago as 1900. From the literature emanating from Java and from conversations with Miss Wilbrink we learn that gall production has never become sufficiently common in their cane cultures to arouse anything more than a curious interest. Their canes have never displayed such aggravated cases as are now frequently met with in several of our cane varieties.

Dr. Mangelsdorf recently called our attention to a paragraph in a paper by C. A. Barber\* setting forth the results of his studies of sugar canes in India. Barber described proliferating stem galls such as we are now concerned with and also notes

\* Barber, C. A. Studies in Indian Sugarcane, No. 4. Memoirs of the Department of Agriculture in India, Botanical Series 10:56-57, 1919.



Fig. 16. At the left is shown a portion of a stick of D 1135 bearing functional internodal roots and a large shield-shaped gall. At the right the same gall is shown enlarged 6.9 diameters. Photos by Twigg Smith.

the simultaneous occurrence of knife-cuts, inferring that gall production may in some cases result from the "cuts." He illustrates his paper with drawings and photographs which leave no doubt but that he is dealing with abnormalities of exactly the same character as those now prevalent in our canes.

We quote Barber as follows:

"But the most striking and frequent case of abnormal bud formations is when they are irregularly produced in different parts of the stem without any regard to the usual position. They are often met with in the root zone, for here there is, more or less permanently, meristematic tissue, but they may also appear at almost any part of the joint. They may arise direct from the outer layers of the stem, but more usually they are preceded by the formation of an irregular mass of callus, over which the buds are distributed unevenly, varying from mere pin points of tissue to fully formed buds with scaly leaves. Curious monstrous forms are thus produced. . . . They would appear to be commoner on seedlings of certain parentage, although they have been found sporadically in almost all the plots, thus conveying the suggestion that the formation of cane plants from seed is no longer governed by the strict rules applicable to seed-bearing plants. In 1917-18 the *Khelia* plot of seedlings was thus marked out as containing numerous examples of this deformity. The cases thus far mentioned do not seem to have their origin in any injury to the cane tissues, but, in other cases, the callus results from the hole of a stem borer, the breaking of a cane, or the curious "cuts" above the bud in the groove, to which attention was drawn in the *Journal of Heredity* of February, 1916. These cuts have been found in many of our seedlings and cane varieties on the farm, and appear not to be the result of any insect or other attack, but on differences in tension of the superficial layers of the stem. They have been found also in seedlings of *Saccharum spontaneum* in some quantity, and various cases have been drawn at intervals during the past five years.

We sent a copy of the October *Record* to Mr. D. S. North in Australia and asked him to read our article on galls and then tell us what he knew about the occurrence of similar galls on canes in Australia and Fiji. His reply is so very interesting that we shall quote it at length:

In reply to your enquiry, I may state that I have seen many examples of external galls on sugar cane stalks, such as you describe. But I have not seen any such extreme cases as are illustrated in your figures 1, 2, 3, and 9, and Kamerling's Fig. 1.

I first noted these galls in 1907, on many stalks of Badila at Lautoka, Fiji. This was at the very commencement of my work on cane diseases (Fiji disease), before even the Fiji disease leaf galls had been noted. At that time I followed them up only until it became apparent that they had no specific connection with Fiji disease. Since then I have casually noted them frequently on stalks of Badila, and in rare cases on other varieties, in Fiji, Queensland, and N. S. W. These galls all corresponded exactly to your description on p. 493, under heading "Nature and Distribution of Galls," except that I have not observed aggravated cases accompanied by distortion, nor galls elaborating leaf tissue. However, adventitious bud production apparently from galls has been noted in a few isolated cases.

We have also had many examples of multiple bud production by newly raised seedling canes, notably by 7R428 (Pompey), in which this habit was particularly marked at first, and still persists to a slight extent after 20 years cultivation (in the tropics but not at N. S. W. mills). In this case, secondary (adventitious) buds spring from the nodes close to and on either side of the primary bud in regular sequence. Nodes bearing a row of 11 and even 13 buds, circling half way round the stalk, have been frequently noted with Pompey in extreme cases. But this phenomenon seems quite independent of that of the galls now under consideration.

"Bunch-tops" are also of common occurrence with us. A photograph of one taken at Rarawai about 1914 is enclosed. (Reproduced herewith as our Fig. 17.) They occur more commonly at the subtropical (N. S. W.) mills than in the tropics. They were exceptionally

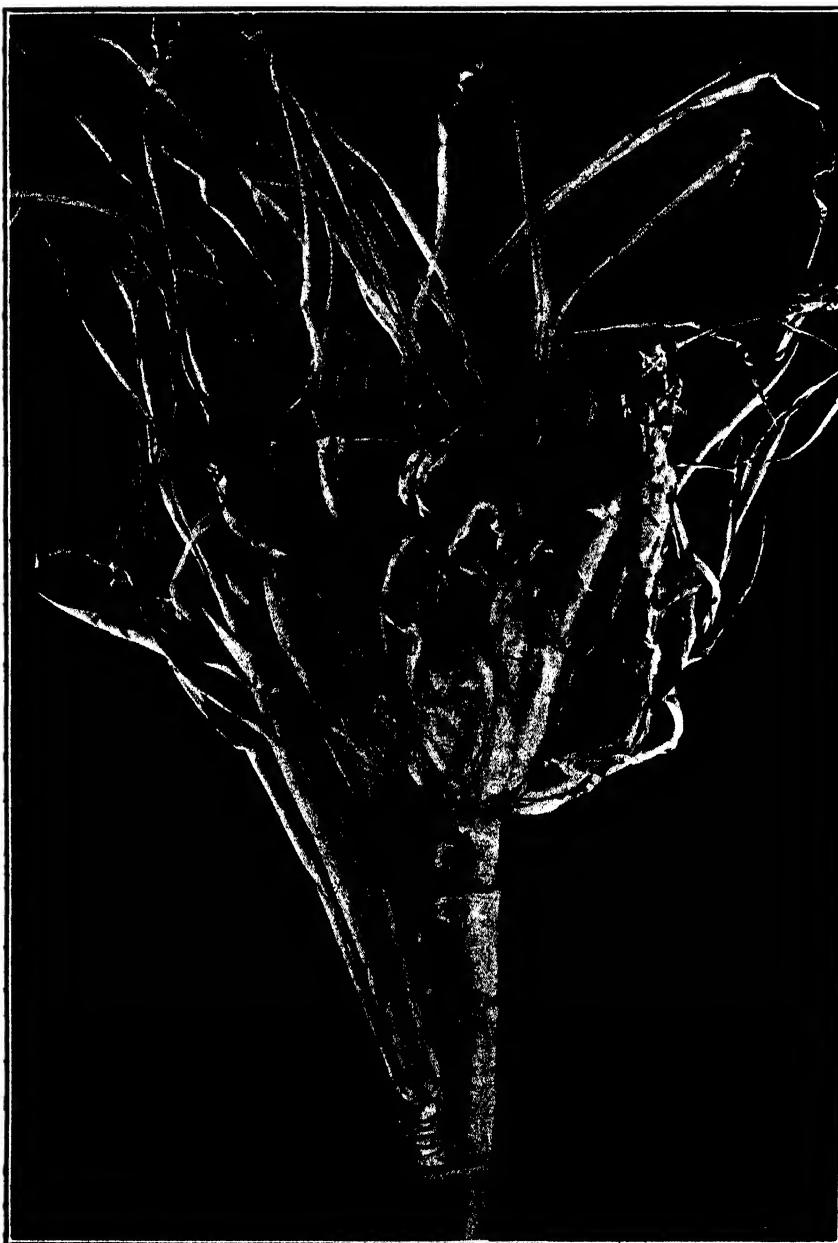


Fig. 17. A bunch-top which was found at Rarawai, Fiji. Photo supplied by Mr. D. S. North.

numerous all over this district last spring. Hundreds of them developed in a small ratoon variety experimental plot of about  $\frac{3}{4}$  acre here at the mill, right under our eyes. The manner in which these bunch-tops are associated with arrowing, to my mind, lends strong support to the hypothesis of aborted arrows. In fact, your earlier conclusion, that "Bunch-top is a malgrowth resulting through the abortion of an inflorescence or tassel. The growing point of the shoot reverts to vegetative growth after starting the development of an inflorescence, and a bunch-top is the result," seems to fit the case exactly. They develop towards the end of the arrowing season, most freely in those varieties which are prone to arrow, commonly in stalks which have pointed up as if to arrow, and so forth. Specimens have been observed which apparently represent reversion to vegetative growth after the inflorescence has reached various stages in its development. Further, no galls are usually found in association with these bunch-tops. Altogether, I feel convinced that this must be the true explanation of most of the bunch-tops which I have seen.

Another kind of bunch-top, closely resembling your Fig. 4, also occurs here, associated with and apparently due to Curly Top disease, in Malabar and the other Tanna varieties. The symptoms characteristic of Knife-cut disease are also frequently associated with Curly Top, as also are symptoms closely resembling those shown in your Fig. 7 (both stalks), and those you describe on p. 498, 4th paragraph. This suggests some relationship between your gall disease and our Curly Top and Knife-cut diseases. The bifid and trifid sticks thus produced are apparently quite distinct from true dichotomous branching, of which I have seen some perfect examples, the canes being quite free from galls, distortion, abnormal leaf scars or other irregularities, which could connect them with bunch-tops.

In view of these observations, I consider that your conclusion that "we must . . . place bunch-top in the category of a gall induced by extraneous forces," may prove inapplicable to all cases. Rather, I think that two, three or more different types of bunch-tops may have to be recognized, especially as your conclusion seems so well founded in the case of the bunch-tops you studied.

In a personal letter to E. L. Caum, W. W. G. Moir states that he observed stem galls on certain of the Java seedlings now growing on the grounds of the Cuba Experiment Station at Santiago de las Vegas.

#### THE CAUSAL FACTOR UNKNOWN

The factor which is causing the production of galls by our canes still remains undetected. While the evidence obtained from field observations strongly supports conclusions that the disease is infectious and spreads from cane to cane, we have not yet proven these conclusions by actual experiments. Many experiments have already been installed to gain information along these lines, but sufficient time has not yet elapsed to yield results.

We are not yet able to estimate the potential danger to the sugar industry which this disease represents. It may be very considerable, and then again it may be quite negligible. A number of the newer seedling canes, such as U. D. 47, 25-Q-88, 25-Q-137 and 26-Q-2673, have been quickly rendered absolutely worthless by the malady and a great many more have had their sticks so disfigured by galls as to make them at least unattractive. It is true that the majority of the canes attacked carry the disease, for a time at least, with little or no apparent loss in vigor or diminution in the size of sticks produced. Galled sticks must, however, expend energy and material in building gall tissue that might otherwise be reserved as sugar. There can be no doubt but that the ratio of juice to fibre is reduced in proportion to the volume of gall tissue elaborated.

It would look as though the majority of our standard big-stick canes are very resistant to the gall disease, and so long as they predominate in our cultures the disease will probably not be of any great economic importance. In many of the seedling canes secured through the crossing of Uba with other varieties, susceptibility to this disease appears to be greatly accentuated. By growing these canes we are cultivating the disease, greatly increasing the volume and distribution of infected and infectious material and possibly educating the causal factor up to a point where it may become more virulent than formerly among our big-stick canes.

A conspicuous feature noted and commented upon by all observers of these cane galls is that they reach their greatest development on the most vigorous and robust sticks of cane: the most succulent sticks exhibit the most aggravated examples of galls. This, however, is to be expected for the influence causing gall production is effective only on the tissues while they are in an embryonic or growing condition. The more rapidly a cane grows the more tissue will be in the embryonic condition at any one time and consequently the better the opportunity to elaborate numerous large galls.

In considering the possible danger to our industry represented by the gall disease we should remember that the mosaic disease presented a very similar problem when it was first recognized in our fields. Some canes were quite evidently seriously injured by it, while others contracted it and maintained such vigor that it took very careful experiments to determine the considerable loss which could not be detected by merely observing the canes in the field. In commenting upon the serious eye spot epidemics which have occurred on certain canes in Hawaii during recent years, Dr. F. A. F. C. Went writes: "The occurrence of eye spot disease is interesting because it shows that we should never underestimate an apparently harmless disease. Eye spot disease has occurred in Java from times unknown without causing any damage to speak of."

## Notes on Yields and Stem Gall Occurrence of Some Uba Quarter-Breeds at Makiki

By J. A. VERRET

These data are from a first harvest of a number of seedlings grown in 1925. They were planted in ten-foot sections with three checks each of H 109, D 1135 and Yellow Caledonia, and one section of Striped U. D. 1.

The cane was planted in March, 1926, and harvested in May, 1927. In planting, three-eye seed pieces with the two end eyes taken out were used. These were spaced one foot between eyes. Extra seed pieces were put in to replant any misses. In this way all the varieties had a uniform stand to begin with.

Previous to harvest and after being cut these canes were carefully inspected for stem galls. Galls were found on eighteen of the forty-two varieties in the plot.

No galls were found on H 109, D 1135, Yellow Caledonia or on Striped U. D. 1, being confined to the quarter-breed Ubas. In no case were these galls of an aggravated nature. They were very small and very few.

The varieties are listed in the order of their yields in the following table. The presence or absence of galls is also indicated:

25 Q SEEDLINGS IN ORDER OF SUGAR YIELD

Variety	Pounds Total Sugar per		Remarks
	10 Feet of Line		
25 Q 229	39.1		
25 Q 158	29.5		Stem galls
25 Q 214	29.4		Stem galls
25 Q 159	29.2		Stem galls
25 Q 156	28.8		Stem galls
25 Q 224	26.1		
25 Q 110	25.9		Stem galls
25 Q 177	25.6		
H 109	24.9		2 plots--27.4 and 22.4
25 Q 188	24.0		Stem galls
D 1135	23.5		3 plots—24.2, 24.2, 22.0
25 Q 25	22.8		
Yellow Caledonia	22.1		2 plots—24.4, 19.8
25 Q 124	21.5		Stem galls
U. D. 1 (Striped)	20.4		
25 Q 11	20.4		Stem galls
25 Q 167	20.1		Stem galls
25 Q 15	19.1		Stem galls
25 Q 18	19.0		Stem galls
25 Q 79	18.2		
25 Q 75	18.1		Stem galls
25 Q 184	18.0		
25 Q 113	16.7		
25 Q 4	15.9		
25 Q 1	15.1		Stem galls
25 Q 195	15.1		
25 Q 36	14.0		
25 Q 61	13.5		
25 Q 34	13.4		
25 Q 194	12.9		
25 Q 27	12.5		Stem galls
25 Q 7	12.1		Stem galls
25 Q 209	12.1		
25 Q 119	11.4		Stem galls
25 Q 162	11.2		Stem galls
25 Q 196	11.2		
25 Q 40	11.0		
25 Q 166	9.7		
25 Q 126	7.9		
25 Q 160	5.4		
25 Q 73	2.9		
25 Q 70	2.2		Stem galls

1925 UBA QUARTER BREEDS. CANES 14 MONTHS OLD AT HARVEST IN MAY 1927.  
 Each section 10 feet long and 5 feet wide. In planting eyes  
 were spaced one foot apart. Varieties with gall are  
 indicated. Those not marked were gall free.

H109 Used for Seed	25Q1 Gall	57 T.C. 5.6 T.S.	25Q4	57 T.C. 6.9 T.S.	D1135	106 T.C. 10.5 T.S.	25Q7 Gall	50 T.C. 5.3 T.S.	25Q11 Gall	105 T.C. 8.9 T.S.	
25Q15 Gall	81 T.C. 8.3 T.S.	25Q18 Gall	66 T.C. 8.3 T.S.	25Q25	99 T.C. 9.9 T.S.	25Q27 Gall	68 T.C. 5.4 T.S.	25Q34	70 T.C. 5.8 T.S.	25Q36 Gall	75 T.C. 6.1 T.S.
25Q40	41 T.C. 4.8 T.S.	25Q61	64 T.C. 5.9 T.S.	Striped U-D1	77 T.C. 8.9 T.S.	25Q70 Gall	25 T.C. 1.0 T.S.	25Q73	25 T.C. 1.3 T.S.	Yellow Caledonia	84 T.C. 10.6 T.S.
Yellow Caledonia	80 T.C. 8.6 T.S.	25Q75 Gall	76 T.C. 7.9 T.S.	25Q79	92 T.C. 7.9 T.S.	25Q110 Gall	114 T.C. 11.8 T.S.	25Q113	66 T.C. 7.3 T.S.	25Q119 Gall	52 T.C. 5.0 T.S.
25Q124 Gall	87 T.C. 9.4 T.S.	25Q126	56 T.C. 3.4 T.S.	25Q156 Gall	132 T.C. 12.5 T.S.	25Q158 Gall	111 T.C. 12.9 T.S.	H109	91 T.C. 9.8 T.S.	25Q159 Gall	117 T.C. 12.7 T.S.
25Q160	41 T.C. 2.4. T.S.	25Q162 Gall	49 T.C. 4.9 T.S.	D1135	86 T.C. 9.6 T.S.	25Q166	68 T.C. 4.2 T.S.	25Q167 Gall	64 T.C. 8.8 T.S.	25Q177 Gall	84 T.C. 11.2 T.S.
H109	98 T.C. 11.9 T.S.	25Q184	62 T.C. 7.8 T.S.	25Q188 Gall	88 T.C. 10.5 T.S.	25Q194	63 T.C. 5.6 T.S.	25Q195	67 T.C. 6.6 T.S.	25Q196 Gall	49 T.C. 4.9 T.S.
25Q209 +106 T.C. 53 T.S	25Q214 Gall	108 T.C. 12.8 T.S	Yellow Caledonia Used for Seed		25Q224	114 T.C. 11.4 T.S.	25Q229	118 T.C. 11.0 T.S.	D1135	106 T.C. 10.5 T.S	

As seen in the above table, as well as on the chart shown here, several of these canes gave yields which indicate them to be worthy of further trial on a more extensive scale. On account of lack of repetitions and the small areas involved these figures are tentative only. But we feel that they give strong indications of the relative ranking of these canes. The conditions under which these canes were grown were very uniform as will be noted from the yields of the various check plots of standard canes listed in the chart before mentioned. This adds to the value of the results.

Seed from the best of these seedlings was taken for further planting. Seed from varieties showing stem gall was planted at the Mid-Pacific plots, while gall-free seed was taken to Kailua.

Reference to the table will show that stem galls were much more prevalent in the better yielding varieties than in the poorer ones. Of the five seedlings giving the best yields four were found with stem galls. We find 67 per cent of the total gall infection in the nineteen which head the list, with only 33 per cent in the poorer half of the lot. Of the nineteen better yielding varieties twelve were found with galls, while only six were found infected in the poorer nineteen. This same condition has been observed before within a variety itself. Generally it is the most vigorous stools and the fastest growing stalks which show the most galls.

The first and natural conclusion one arrives at from this condition of affairs is that vigorous canes are more susceptible to gall attack and that the presence of galls in most cases has very little, if any, depressing effect on the yields. But another remote possibility presents itself to which we feel attention should be called. Galls are formed by abnormal cells. These abnormal cells are the result of some unnatural stimulation in the plant produced by some unknown cause.

Now, it might be possible that the stimulation which causes the formation of these abnormal cells may also stimulate the formation of normal ones and thereby cause some increase growth in cases when the gall attack is not too severe.

We do not intend this to mean that we should disregard galls. We feel that until we know more about them we should all be very careful how we spread the more susceptible varieties.

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## The Effect of Fertilizer Constituents on Eye Spot at the Waialua Agricultural Company, Ltd.

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The following experiment was undertaken to determine conclusively the relation of fertilizer programs to eye spot occurrence, not only of the nitrogen constituents, but also of potash and phosphoric acid.

In Field Valley 1B at the Waialua Agricultural Company, growing H 109 planted June, 1926, a checkerboard test was laid out in which 10 plots were treated with high amounts of nitrogen, 10 plots with no nitrogen, 10 plots with high potash, 10 plots with no potash, 10 plots with high phosphoric acid, 10 plots with no phosphoric acid, and 10 plots with usual plantation fertilizer practice. These fertilizers were applied on August 26, 1926. The amounts of each of the different fertilizer constituents used are shown in the upper left-hand part of Fig. 1.

The amounts of eye spot infection in each plot were measured by means of infection counts of 200 leaves per treatment. These were secured by selecting 20 stalks well distributed in each plot, and marking each stalk with a red cloth for subsequent identification. On each stalk the third leaf from the youngest was selected and the eye spot infections counted; since there was one leaf on each stalk, and 20 stalks per plot, this made 20 leaves counted per plot, and with 10 replications of each fertilizer treatment, there were infection counts on 200 leaves for each treatment. The total infections on these leaves were then averaged per leaf. Such infection counts were made at two-week intervals beginning on August 30.

The average infections per leaf for each treatment are charted in Fig. 1.

Examining this figure, one sees that infections averaged less than 1 per leaf until November 22. Infections then began to increase and reached the first peak on February 14; favorable weather then brought about a recession in eye spot for two weeks, but severe eye spot weather then set in causing a second much more severe infection on March 28.

From November 22 onward eye spot was consistently most severe in the plots treated with high nitrogen; the plots receiving no nitrogen were consistently less affected than the other plots. Plots with no nitrogen averaged but 32.8 infections per leaf at the highest peak of infection, which would cause but negligible injury to the cane plant. Plots with 65 pounds of nitrogen per acre averaged 58 infections per leaf or 77 per cent more than the plots with no nitrogen. Plots with

*FIG. 1.—THE EFFECT UPON EYE SPOT OF APPLICATIONS OF THE VARIOUS FERTILIZER CONSTITUENTS TO THE CANE*

LOCATION: WAI'AU AGRICULTURAL CO., LTD. FIELD VALLEY 15  
DATE: AUGUST 30, 1926 TO MARCH 28, 1927.

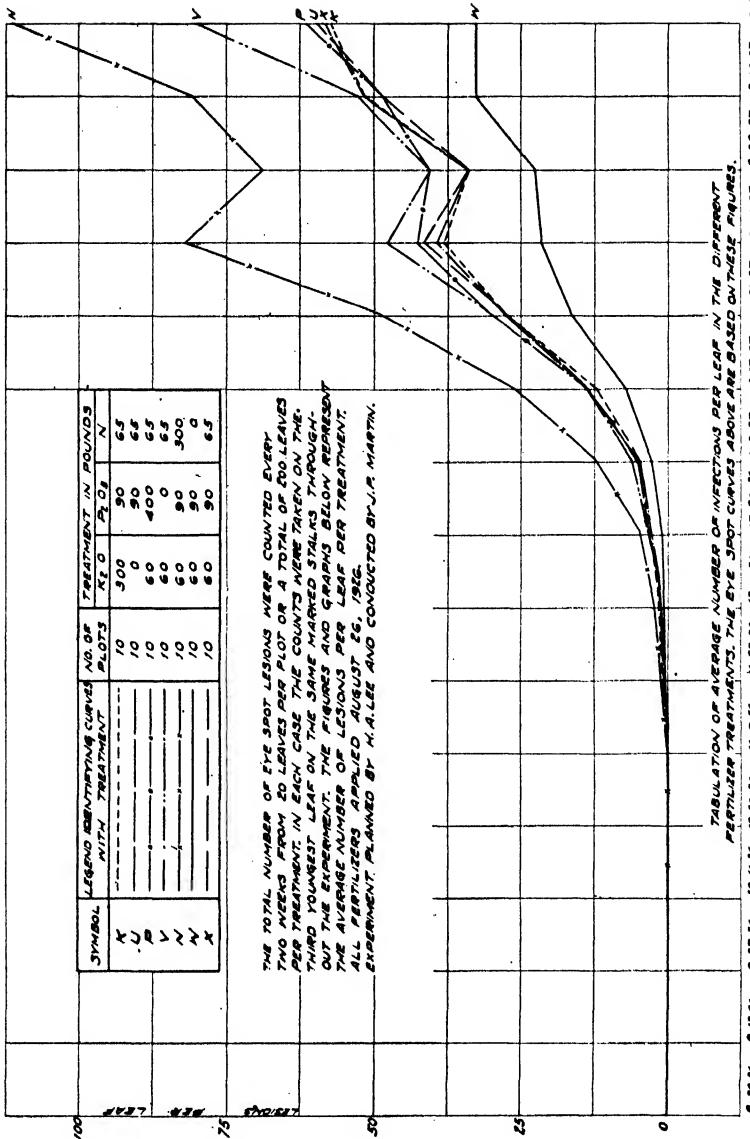
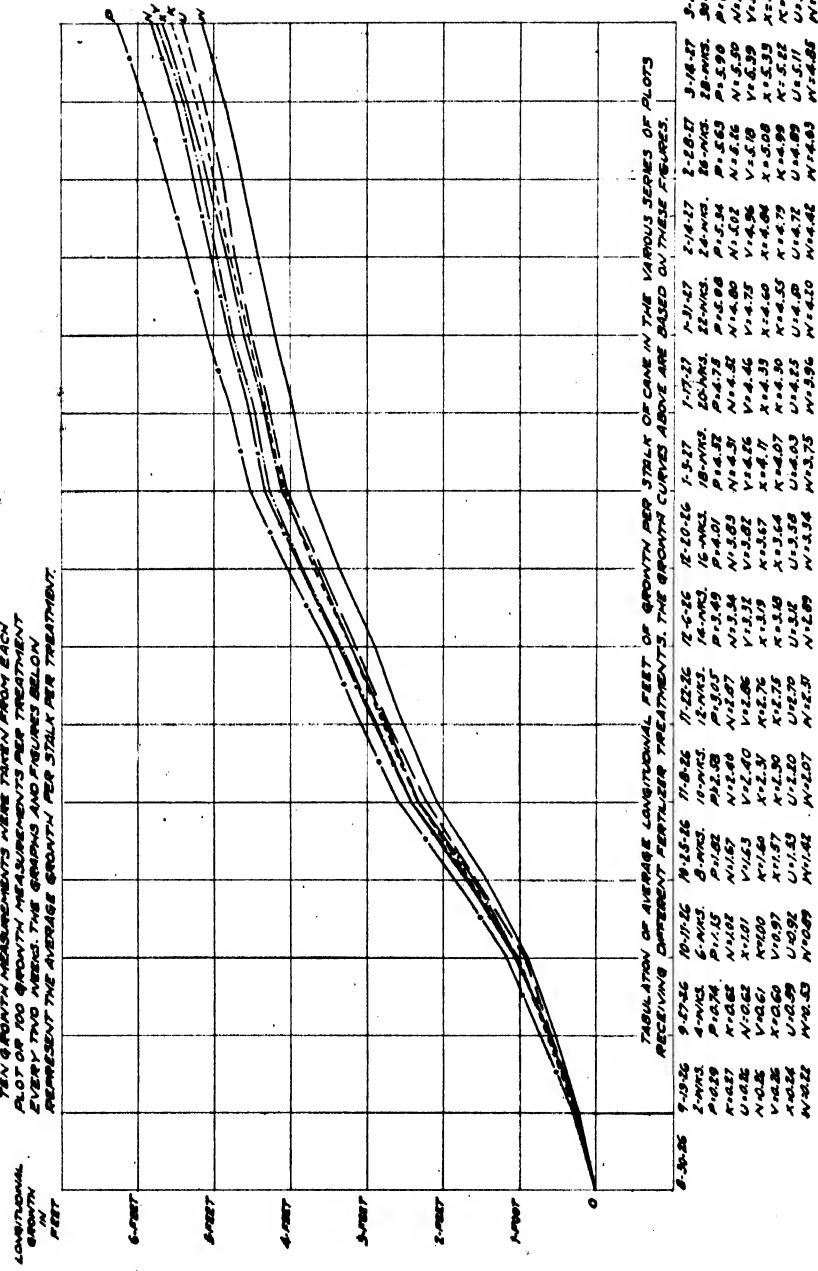


TABLEAU OF AVERAGE NUMBER OF INFECTIONS PER LEAF IN THE DIFFERENT  
SCHISTOSOMIC TREATMENTS. THE EYE SPOT CURVES ABOVE ARE BASED ON THESE FIGURES

Fig. 1

**FIG. 2:-** GROWTH MEASUREMENTS FROM THE FERTILIZER TREATMENTS SHOWN IN FIGURE 1  
THE CURVES IDENTIFYING THE TREATMENTS ARE THE SAME AS IN FIGURE 1



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300 pounds of nitrogen per acre averaged 111 infections per leaf or 238 per cent more infections than the plots with no nitrogen.

It seems established therefore that nitrogen applications in the fall months increase eye spot infection.

Turning to the phosphoric acid applications; in this field, plots with no phosphoric acid had more infection consistently throughout the experiment than the plots with 400 pounds of phosphoric acid per acre, and at the first peak of infection there was 12 per cent more infection in the plots with no phosphoric acid. At the second peak of infection there was 28 per cent more infection in the no phosphoric acid plots than in the high phosphoric acid plots. From the results of this experiment alone it would be difficult to say that these results were significant and that phosphoric acid applications reduced eye spot, since the differences were not large and might be due to chance. However, it is well to keep these results with phosphoric acid in mind.

At both high peaks of infection, plots with 300 pounds of potash per acre had slightly less infection per leaf than plots with no potash per acre, but the differences in this case are also so slight that one cannot be sure but that these differences are merely due to chance. Nevertheless these results should also be kept in mind.

Turning to the growth curves shown in Fig. 2, one is surprised to observe that in this field phosphoric acid gave a better growth response to the cane than the nitrogen. The plots treated with 400 pounds of phosphoric acid per acre averaged 7.2 inches more longitudinal growth per stalk than the plots with usual plantation practice (90 lbs.  $P_2O_5$  p. a.), a very profitable increased yield in seven months from time of application. The plots with 300 pounds of nitrogen per acre averaged 1.8 inches more longitudinal growth per stalk in seven months, than the usual plantation practice (65 lbs. N per acre at this application). Potash applications did not increase growth in this field.

#### SUMMARY

With ten replications of plots for each treatment the following conclusions seem warranted:

(1) Phosphoric acid applications materially increased the longitudinal growth of the cane in this experiment, considerably more so than nitrogen applications.

(2) However, increased growth from phosphoric acid did not result in increased eye spot. The reverse occurred; plots treated with 400 pounds of phosphoric acid showed smaller eye spot counts at the peaks of infection than plots with no phosphoric acid. The differences in infection, however, do not seem to be large enough to be significant at least from these results alone, but should be kept in mind in connection with subsequent experiments.

(3) The plots with 300 pounds of potash per acre showed less eye spot than the plots with no potash quite consistently throughout the experiment and more pronounced at the two peaks of infection. However, the differences in infection are not sufficiently great to be significant, at least from the results of this experiment alone. Nevertheless these results should also be kept in mind.

(4) Applications of inorganic nitrogen fertilizers to H 109 cane in the late summer and fall months, in fields with topography and climatic conditions favorable to eye spot, greatly increased the severity of the disease.

(5) The conclusion is evident that applications of fertilizers containing inorganic nitrogen should not be applied in the late summer or fall months, to fields of H 109 with a history of eye spot or where, from the topography of the field eye spot would be expected to be severe.

Experiment laid out and conducted by J. P. Martin, with the cooperation of the Waialua Agricultural Company, Ltd.

Experiment planned by H. Atherton Lee.

H. A. L.

## The Effect of Fertilizer Constituents on Eye Spot at the Kilauea Sugar Plantation Company

In Field 36 at the Kilauea Sugar Plantation Company the effect of the various fertilizer constituent tests upon eye spot was tested out in a checkerboard field test. The eye spot intensity was compared between series of plots of cane treated with very high applications of nitrogen fertilizers, plots with more moderate applications of nitrogen, plots with high applications of phosphoric acid, plots with moderate applications of phosphoric acid, plots with high applications of potash, plots with moderate applications of potash, and plots of usual plantation practice. The fertilizers of usual plantation practice were applied in July, 1926, and the fertilizers with the high rates of applications of the various constituents were applied in September, 1926. In each series of fertilizer treatments there were six replications of plots. The layout of the experiment is shown to the left in Fig. 1.

The cane in this field consisted of H 109, second ratoons, previously harvested in July, 1926. The plots consisted, each of 6 rows of cane, running from level ditch to level ditch as shown in Fig. 1.

The amounts of the fertilizer constituents applied in September were excessively high, for the purpose of accentuating any differences which might occur in the severity of eye spot infection resulting from the various treatments. The amounts of such constituents are also shown in the table in Fig. 1.

The severity of eye spot infection was measured in the different plots, from eye spot counts, made as described in previous experiments; in the case of this test such eye spot counts were made from the 2 youngest leaves per stalk, from 20 stalks per plot. Since there were 6 replications of plots for each treatment there were thus 240 leaf counts of infections for each treatment. Such eye spot counts were made every two weeks.

The average infections per leaf in each series of plots of the different fertilizer treatments are charted in Fig. 1.

Disregarding the effect of the different fertilizer treatments on the disease, for the time being, it can be seen from Fig. 1, that in Field 36, infections averaged less than 3 per leaf up to November 19, 1926. Infections per leaf then multiplied

THE EFFECT UPON EYE SPOT OF APPLICATIONS OF THE VARIOUS  
FERTILIZER CONSTITUENTS TO THE CANE.

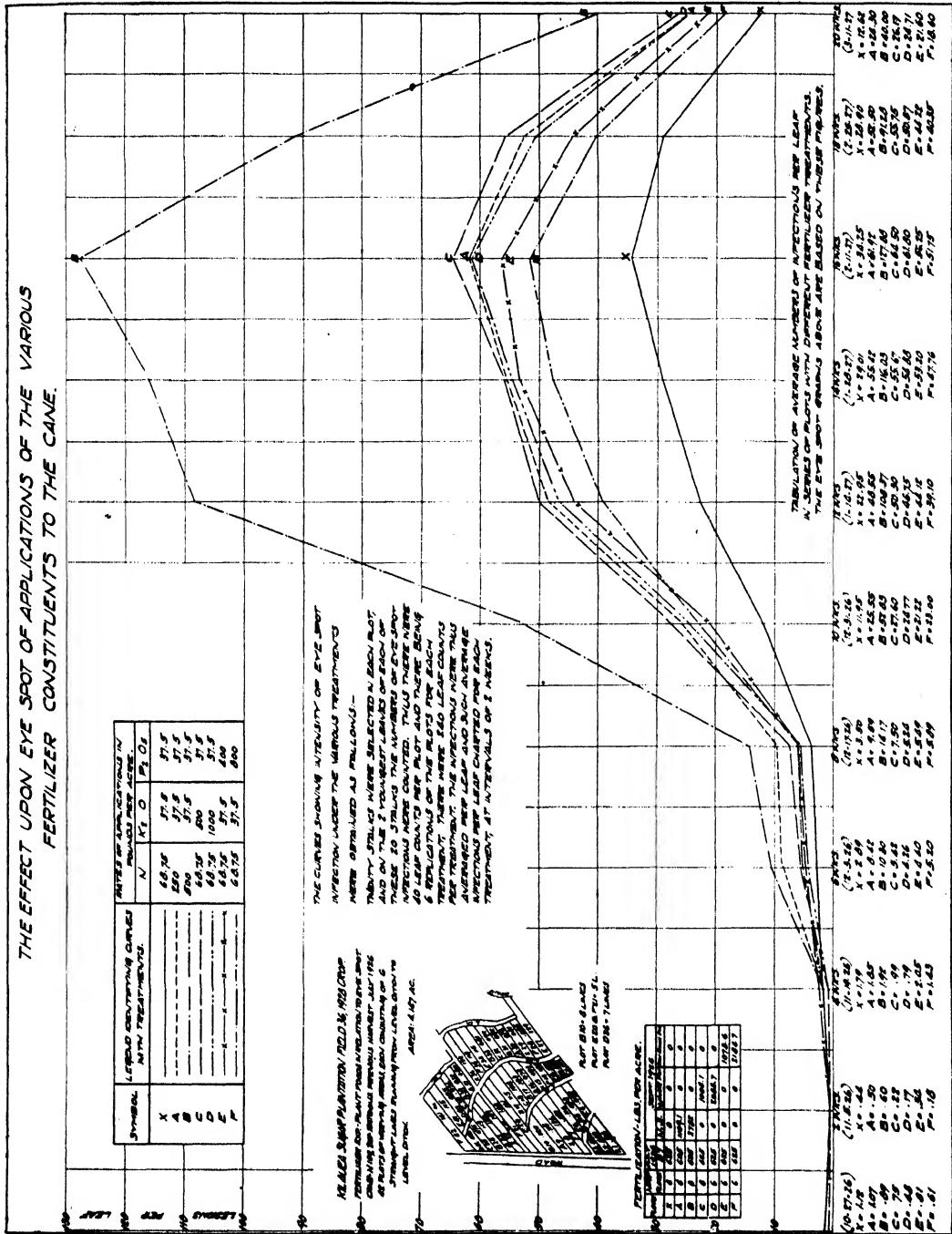


FIG. 1

rapidly during December and January, reaching the peak of infection on February 11, in this field, and then decreasing rapidly during March. This peak of eye spot infection in the winter months is a usual thing, and is explained naturally by the shorter length of days in November, December and January with longer periods of dew on the leaves, and more moisture on the leaves from the more frequent winter rains.

Turning attention to the effect of the different fertilizer constituents on eye spot infection, it can be seen from the eye spot graphs in Fig. 1 that high applications of nitrogen fertilizers tremendously increased the severity of the disease. Yet if one observes the growth curves in Fig. 2, it can be observed that nitrogen produced no growth response in this field at Kilauea; the absence of a growth response from nitrogen applications is not an uncommon thing at Kilauea. Yet in spite of the absence of a growth response, inorganic nitrogen fertilizers increased eye spot severely.

Our previous conception of the effect of fertilizers, particularly nitrogen, in increasing eye spot, was that a more soft, succulent growth was produced which was susceptible. These results at Kilauea showing no growth response from nitrogen applications, but an immense eye spot reaction, alter our previous conception of the role of nitrogen fertilizers in increasing eye spot. The decided growth response from phosphoric acid fertilizers in Field Valley 1B at Waialua, with no corresponding eye spot increase, while nitrogen fertilizers greatly increased infection without as great a growth increase in the cane, is in support of these results at Kilauea, indicating that the increase in eye spot following nitrogen fertilizer applications is not due to soft, more succulent cane. The logical conception at present is, that the inorganic nitrogen gets into the cane juices of the leaves and such juices then provide a better medium for the development of the eye spot fungus, than juices without inorganic nitrogen.

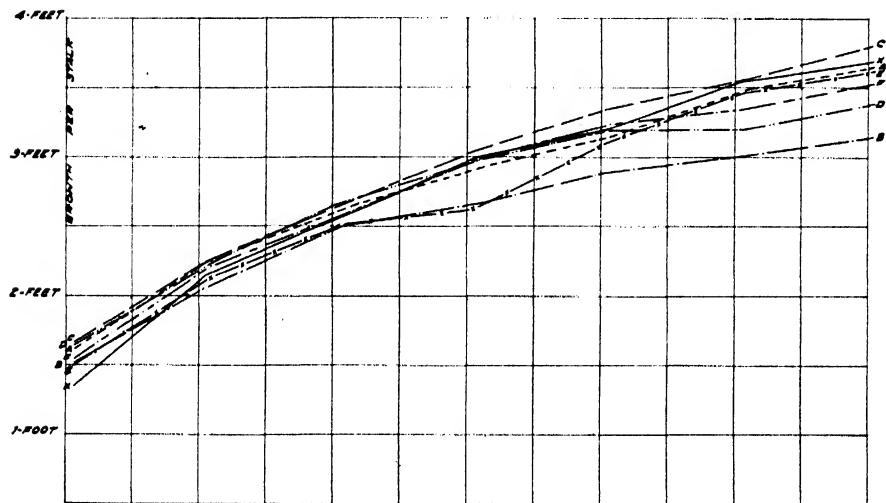
From an abstract viewpoint the results are of interest in an effort to increase resistance of H 109 to eye spot, by a study of the supply of nutrients.

From a plantation viewpoint, the results indicate clearly that applications of fertilizers containing nitrogen in H 109 fields of probable eye spot occurrence, should be avoided in the late summer and fall months, in order to escape the eye spot response during the winter months of short daylight, longer periods of dew, and greater probabilities of wet leaves from rainfall and kona weather. In theory, applications of nitrogen fertilizers should be made to such fields at such a time that the physiological response would occur in May, June or July, during the period of the greatest length of sunlight, less persistent dew on the leaves, and less chances for rainfall.

In Fig. 1, it can be seen that the eye spot response is greater from moderate applications of potash (Curve C) than from large amounts of potash (Curve D). This difference in favor of the large applications of potash was consistent through most of the period of the experiment. The decrease in eye spot was not great, and possibly is not significant, but at least merits passing note, for consideration in connection with subsequent experiments.

**FIG. 2:- GROWTH MEASUREMENTS FROM THE FERTILIZER TREATMENTS SHOWN IN FIGURE 1**  
**THE CURVES IDENTIFYING THE TREATMENTS ARE SAME AS IN FIGURE 1**

GROWTH CURVES ARE BASED ON 10 GROWTH MEASUREMENTS PER PLOT AND WITH 6 REPLICATIONS OF THE PLOTS OF EACH TREATMENT THERE ARE THEREFORE 60 GROWTH MEASUREMENTS PER TREATMENT. THE LAYOUT OF THE EXPERIMENT IS SHOWN IN FIGURE 1.



TABULATION OF AVERAGE GROWTH IN FEET PER STALK OF CANE IN PLOTS WITH DIFFERENT FERTILIZER TREATMENTS. THE GROWTH CURVES ABOVE ARE BASED ON THESE FIGURES.

(1 MONTH)	2 MONTHS	4 MONTHS	6 MONTHS	8 MONTHS	10 MONTHS	12 MONTHS	14 MONTHS
A+1.61	A+2.14	A+2.65	A+3.03	A+3.14	A+3.47	A+3.60	A+3.69
B+1.57	B+2.07	B+2.49	B+2.66	B+2.89	B+3.00	B+3.13	B+3.23
C+1.66	C+2.14	C+2.65	C+3.05	C+3.13	C+3.36	C+3.50	C+3.61
D+1.64	D+2.12	D+2.67	D+2.96	D+3.18	D+3.19	D+3.37	D+3.47
E+1.60	E+2.12	E+2.60	E+2.83	E+3.11	E+3.46	E+3.52	E+3.62
F+1.53	F+2.17	F+2.57	F+2.91	F+3.13	F+3.33	F+3.32	F+3.32
X+1.34	X+2.18	X+2.36	X+2.93	X+3.18	X+3.34	X+3.49	X+3.69

Fig. 2

Also plots with large applications of phosphoric acid (Curve F) showed less eye spot than plots with more moderate applications of phosphoric acid (Curve E). The difference here is also slight and in itself is of questionable significance. In connection with similar results at Waialua it is also suggestive that phosphoric acid decreases eye spot slightly. It would be expected that the effect of phosphoric acid and potash fertilizers, if any, on eye spot would vary in different fields of different soil complexes. It can be concluded at least that applications of phosphoric acid and potash fertilizers may produce growth responses, without increasing eye spot infection.

The effect of the time of application of fertilizers on eye spot is shown to some extent by comparing the curve for plots treated with usual plantation practice (Curve X) in which, nitrogen, phosphoric acid and potash, all were applied in July, with curves A, B, C, D, E, and F in which applications of fertilizer constituents were made in September. The evidence in this case is very clear that early applications of fertilizers result in a considerable avoidance of eye spot infection.

#### SUMMARY

(1) Nitrogen fertilizers in September at high rates of application in an H 109 field favorable to eye spot occurrence, greatly increased eye spot, although no growth response resulted to the cane.

(2) Plots treated with potash fertilizers at high rates of application showed slightly less eye spot than plots with more moderate rates of potash application.

(3) Plots treated with phosphoric acid fertilizers at high rates of application showed slightly less eye spot than plots with more moderate rates of phosphoric acid application.

(4) Plots receiving usual plantation fertilizer practice at Kilauea, in which all fertilizer constituents were applied in July, showed much less eye spot than the plots receiving fertilizer applications in September.

Experiment laid out and conducted by Royden Bryan with the cooperation of the Kilauea Sugar Plantation Company.

Experiment planned by H. Atherton Lee.

H. A. L.

## The Effect of Potash Fertilizers on Eye Spot at the Waimanalo Sugar Company

This test was carried on in H 109 second ratoons in Field 14 at the Waimanalo Sugar Company. Eight plots, each plot of 10 rows, each row 30 feet long, were treated with sulphate of potash at the rate of 600 pounds per acre early in October, 1926. Eight alternating plots were left untreated as controls. All plots had previously received the usual plantation fertilizer practice of 185 pounds of nitrogen, 55 pounds of phosphoric acid, and 55 pounds of potash per acre, and with

the exception of the potash treatments all plots were treated identically as to cultivation, irrigation and fertilization.

The degree of eye spot infection in the different plots was measured by means of eye spot counts. In each plot, 20 stalks were selected and marked with a red cloth for future identification. Thereafter at two-week intervals the number of infections on the two youngest leaves of each of these stalks was counted. Since there were two leaves per stalk and 20 stalks per plot, there were counts made on 40 leaves per plot, and with 8 replications of the plots of each treatment there were thus 320 leaves counted for each treatment. The numbers of infections were then averaged per leaf from the counts made on these 320 leaves per treatment.

The average infections per leaf in the plots treated with potash, and in the untreated plots, are charted throughout the eye spot season in the illustration. It can be seen that infection at Waimanalo started to increase materially in both series of plots on February 3, 1927, and reached a first peak of infection, an average of 155 lesions per leaf, on March 3. Due to severe weather favoring eye spot, there was a second peak of infection, averaging 364 infections per leaf, on April 4, and then a rapid decrease in four weeks to less than 10 infections per leaf on May 9.

One of the outstanding features shown in this chart is the high degree of infection as late in the year as April. Another notable feature is the rapid decrease in eye spot in May, due entirely to natural causes such as steady northeast trade winds and greater periods of sunshine.

At the first peak of infection the plots with potash averaged 10 infections per leaf less than the plots without the potash treatment. At the second peak of infection, plots with potash averaged 17 infections per leaf less than the plots without the potash treatment. One is inclined to question whether this lessened infection is due to chance or actually is brought about by the applications of potash. An analysis of the data at the peaks of infection, as shown in Table 1, indicates that the results are fairly consistent in that the plots with potash treatment in a large proportion of plots had less average lesions per leaf than the untreated plots.

TABLE 1

Showing Average Infections per Leaf in Each Plot, During the Period of High Infection

Plot No.	Average infections per leaf			
	March 3	March 19	April 4	April 20
1 K .....	120	41	222	296
2 X .....	127	76	248	183
3 K .....	100	54	200	173
4 X .....	115	100	263	207
5 K .....	149	211	296	220
6 X .....	98	66	319	233
7 K .....	146	67	286	260
8 X .....	125	85	326	242
9 K .....	119	81	234	201
10 X .....	156	161	246	187
11 K .....	173	141	277	180
12 X .....	219	69	273	230
13 K .....	169	70	263	180
14 X .....	223	97	269	169
15 K .....	187	76	90	155
16 X .....	161	91	251	196

**FIG. 1:- THE EFFECT OF POTASH AS A FERTILIZER AGAINST EYE SPOT AT THE WAIMANALO SUGAR CO.**

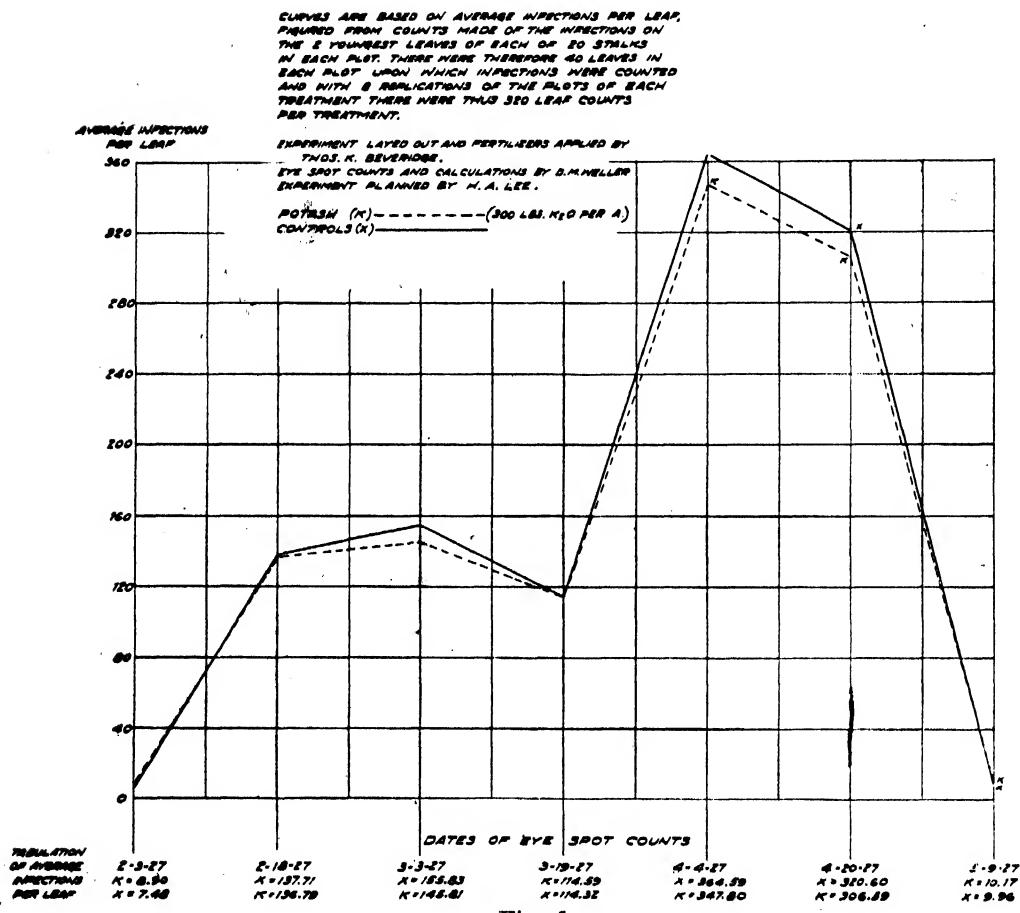


Fig. 1

Briefly, a preponderant proportion of the alternating plots treated with potash, shows less eye spot as shown in Table 1, than the plots without potash treatment.

These results in conjunction with the results at the Waialua Agricultural Company and the Kilauea Sugar Plantation Company, in which potash applications also reduced eye spot infection slightly, lead to the feeling that such potash applications do lessen eye spot definitely, at least in the fields in which the tests were carried on. The reduction in eye spot secured from such treatments was not large, but very often the difference of 10 or 15 infections per leaf is the difference between top rot and merely leaf infection; the former resulting in severe injury to the crop, and the latter resulting only in minor injury.

#### SUMMARY

At the peaks of eye spot infection 8 plots of cane with applications of potash fertilizers to the soil averaged slightly less infection per leaf than untreated plots.

Experiment laid out by Thos. K. Beveridge.

Eye spot counts by D. M. Weller.

Experiment planned by H. Atherton Lee.

H. A. L.

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## The Effect Upon Eye Spot of Increased Time Intervals Between Irrigation Applications

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In theory there seem to be three factors contributing to eye spot infection of H 109 cane which are affected by lessening irrigation water. The first is the lessened dew, which results from having a dry soil surface which is not evaporating moisture into the air to subsequently condense on the cane leaves. In other words, apparently much of our dew is formed from atmospheric humidity which has resulted from the evaporation of moisture from a wet soil surface. If the soil surface is not kept constantly wet by frequent irrigation applications, dew on the cane leaves is consequently reduced. The second factor influenced by decreased irrigation water is transpiration of the cane leaves; less irrigation means less transpiration by the cane leaves and consequently less dew on the leaves. The third effect, in theory at least, is on the plant itself, which when irrigation is withheld is not as soft and succulent and therefore not as susceptible as when irrigation is frequent.

To determine the practical value of such lessened irrigation, and also its effect on the cane growth, an experiment was undertaken with five series of ten plots each, each series having different time intervals between the applications of irrigation. This test was undertaken in Field Gay 3 of the Waialua Agricultural Company, the ratoons of which were started in June, 1926. In the experiment

FIG. 1.—THE EFFECT UPON EYE SPOT DISEASE OF DECREASED IRRIGATION, RESULTING FROM INCREASED TIME INTERVALS BETWEEN IRRIGATION APPLICATIONS

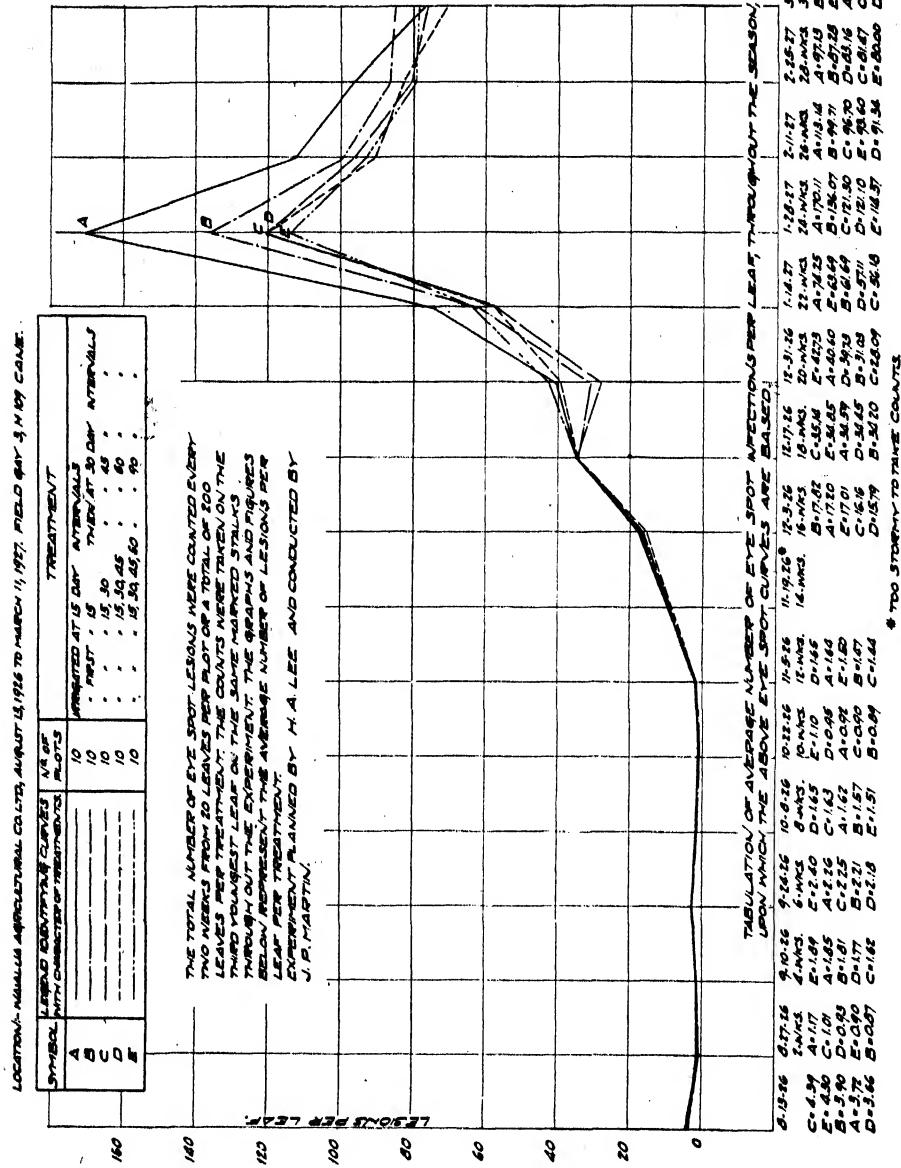


Fig. 1

there were 50 plots, each plot containing ten 30-foot lines of cane. All plots received identical fertilizer and cultivation practices. Of these 50 plots, 10 were irrigated at 15-day intervals. Ten alternating plots were irrigated first with one 15-day interval and then the intervals between irrigation applications were increased to 30 days. Ten additional plots were irrigated, first with one 15-day interval, then one 30-day interval, from then on at 45-day intervals. Ten additional plots were irrigated, first at 15-, then at 30-, then at 45- and finally at 60-day intervals. The fifth series consisting of 10 additional plots, was irrigated first at 15-, then at 30-, 45-, 60- and finally at 90-day intervals. The arrangement of plots is shown in the lower part of Fig. 2.

It will be seen therefore, that the cane was not suddenly cut off from water in any of the series, but a process of tapering off on irrigation applications was inaugurated, to bring the longest intervals between applications in the period expected to be most favorable for eye spot infection. In the case of a rain which was equal to an irrigation application, no water was applied to the experiment at that time. Rainfall from light showers was disregarded, however. All plots received the first irrigation application of the experiment on August 15, 1926.

In each plot 20 stalks were marked with a red cloth for future identification, and at two-week intervals the number of eye spot infections were counted on the third youngest leaf of each of these stalks. Since there were ten plots of each treatment, there were thus 200 leaves from which the numbers of infections were averaged per leaf.

The increase in eye spot in each series of plots during the winter months, is shown in Fig. 1.

By reference to Fig. 1, one sees that eye spot infection was negligible and averaged less than 2 infections per leaf during August, September, October and early November. On November 5 infection started to increase and reached the peak, in this field, on January 28, averaging 170 infections per leaf. During this time, the plots receiving irrigation at 15-day intervals showed more eye spot per leaf consistently. At the peak of infection there were 34 infections per leaf more in such plots than in the plots receiving water at 30-day intervals, a difference amounting to 20 per cent. There were 49 more infections per leaf than in the plots receiving water at 45- and 60-day intervals, a difference amounting to 28 per cent. With water at intervals greater than 45 days there was but slight reduction in infection, in this experiment.

Since there were ten replications of the plots for each irrigation treatment, the results should be accurate. It seems a safe conclusion that lessening irrigation to 45-day intervals between applications, materially reduced eye spot. A decrease amounting to 34 or 49 infections per leaf such as was obtained is often the difference between complete top rot of the cane, and leaf infection from which the cane quickly recovers.

Turning to the growth in the plots of the various irrigation series, shown in Fig. 2, it can be seen that on March 11, at the end of the experiment, the cane in B plots in which the irrigation was lessened to applications at 30-day intervals, actually showed more longitudinal growth per stalk than the cane in plots

**FIG. 2:- THE EFFECT UPON CANE GROWTH OF DECREASING THE FREQUENCY OF IRRIGATION APPLICATIONS IN EYE SPOT FIELDS**

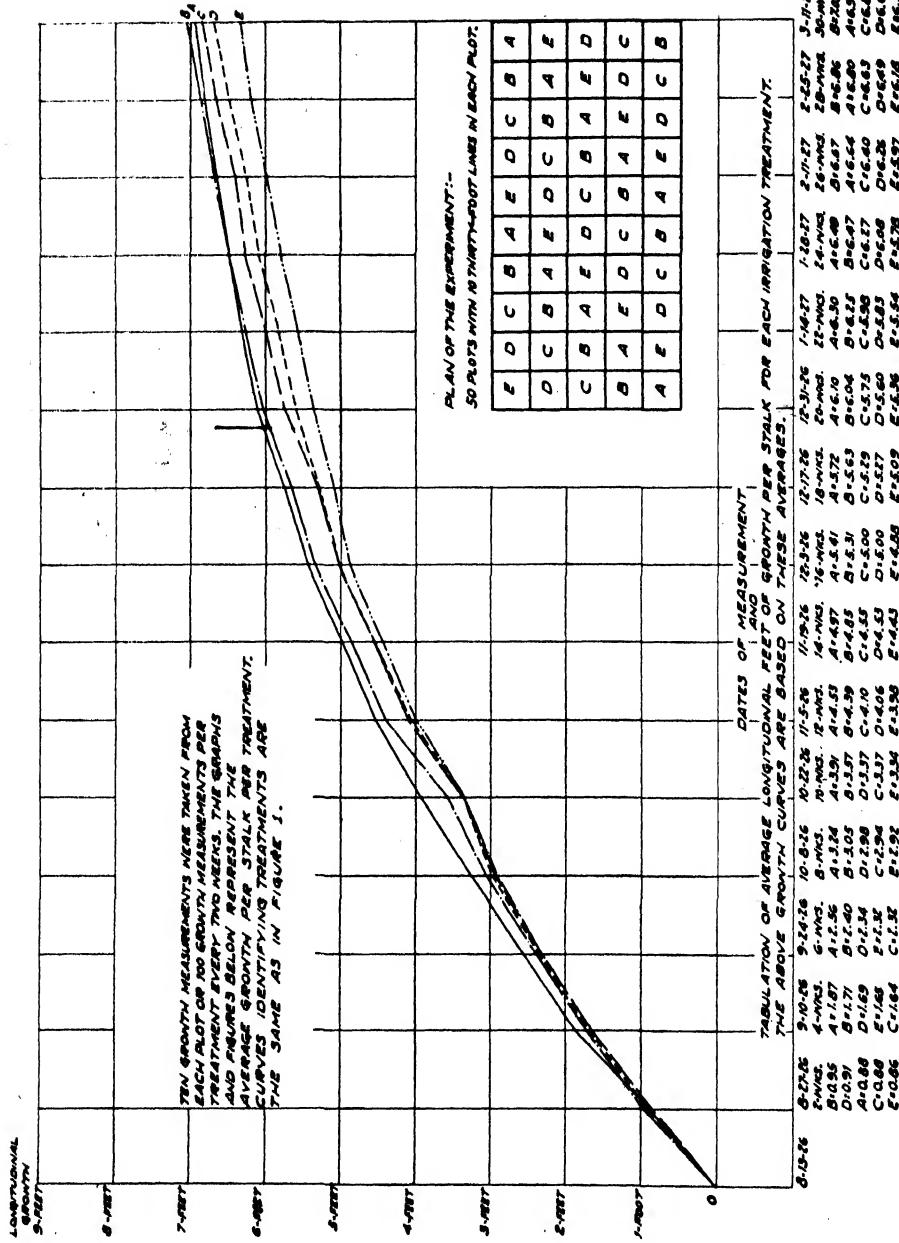


Fig. 2

with 15-day interval water. On the other hand, the cane in plots in which the water was tapered off to a 90-day interval between applications lost  $7\frac{1}{5}$  inches of growth as compared with the cane irrigated at 15-day intervals. This is obviously too great a loss to be compensated for by the reduced eye spot. However, if one analyzes the growth chart throughout the season other conclusions can be drawn. Running backward over the growth curves to December 31, one sees that the loss in growth on that date amounted to 8.9 inches in growth, a greater loss than occurred at the end of the experiment. In other words, after December 31 the cane with 90-day intervals between irrigation actually gained in longitudinal growth on the cane with 15-day interval water. This is equally true of the cane in plots with 60-, 45- and 30-day intervals between irrigations; the cane in all of these plots gained in growth during the cold months, as compared with the cane in the plots with 15-day interval water.

The autumn months of 1926 were warm, with unusually high temperatures recorded for these months. During these warm months the growth in plots with 15-day interval irrigation applications exceeded in growth the plots with lessened irrigation. But with the lowering in temperatures, the growth curve of the plots with 15-day irrigation, flattened off and the growth was better in all of the plots with lessened irrigation.

These results support the conclusions advanced by George F. Renton and William P. Alexander at the last annual meeting of the Association (1926), at which they presented growth results with maximum, moderate and minimum applications of water. They found that in the winter months better growth resulted from the minimum applications of irrigation.

If one were to analyze the growth curves in Fig. 1, still further, one would conclude that if the curves for the 30- and 45-day irrigation (B or C) were cut off on the December 31 date line and superimposed on the 15-day irrigation curve (A), more growth would have resulted than was obtained in any of the series.

The conclusion from an agricultural viewpoint alone, independent of the viewpoint of disease control, would seem to be that less irrigation in the winter months will result in greater cane growth. From our temperature data, the conclusions would be drawn that this lessened irrigation should not be based on the month of the year, but on the temperatures being recorded at the time, as well as the rainfall. Winds or absence of winds are also undoubtedly a large factor to be considered in this matter of frequency of irrigation in the winter months, in relation to cane growth and eye spot occurrence.

#### SUMMARY

Based on an experiment with ten replications of plots, with 200 leaf counts for eye spot intensity and 100 growth measurements for each treatment, the following conclusions seem evident:

(1) Decreasing irrigation by lengthening the intervals between applications definitely lessened the amounts of eye spot infection. A cane with 90 to 100 infections per leaf is much more probable to succumb to top rot than a cane with

60 to 70 infections per leaf. Such a difference was obtained with lessened irrigation, and is thus sufficient to avoid much of the serious loss from top rot.

(2) Such lessened irrigation lessened longitudinal growth during the warm months, but increased growth during the cold months.

(3) It seems reasonable to believe that discretion in the use of irrigation, watching closely the temperatures being recorded during the season, the wind movement, as well as the rainfall, may be made to minimize eye spot and increase cane growth.

Experiment laid out and conducted by J. P. Martin with the cooperation of the Waialua Agricultural Co., Ltd.

Experiment planned by H. Atherton Lee.

H. A. L.

## The Effect of Frequency of Irrigation Applications on Eye Spot at the Lihue Plantation Company, Ltd.

The effect of lessening the frequency of irrigation applications upon the severity of eye spot was tested out in an experiment at the Lihue Plantation Company. The experiment was laid out in Field Lihue 4, of H 109, first ratoons, 1928 crop. All plots received identical fertilizer and cultivation treatments, the only variables being in the intervals between irrigation applications. Due to the exigencies of the field layout but one plot per treatment was possible in this field.

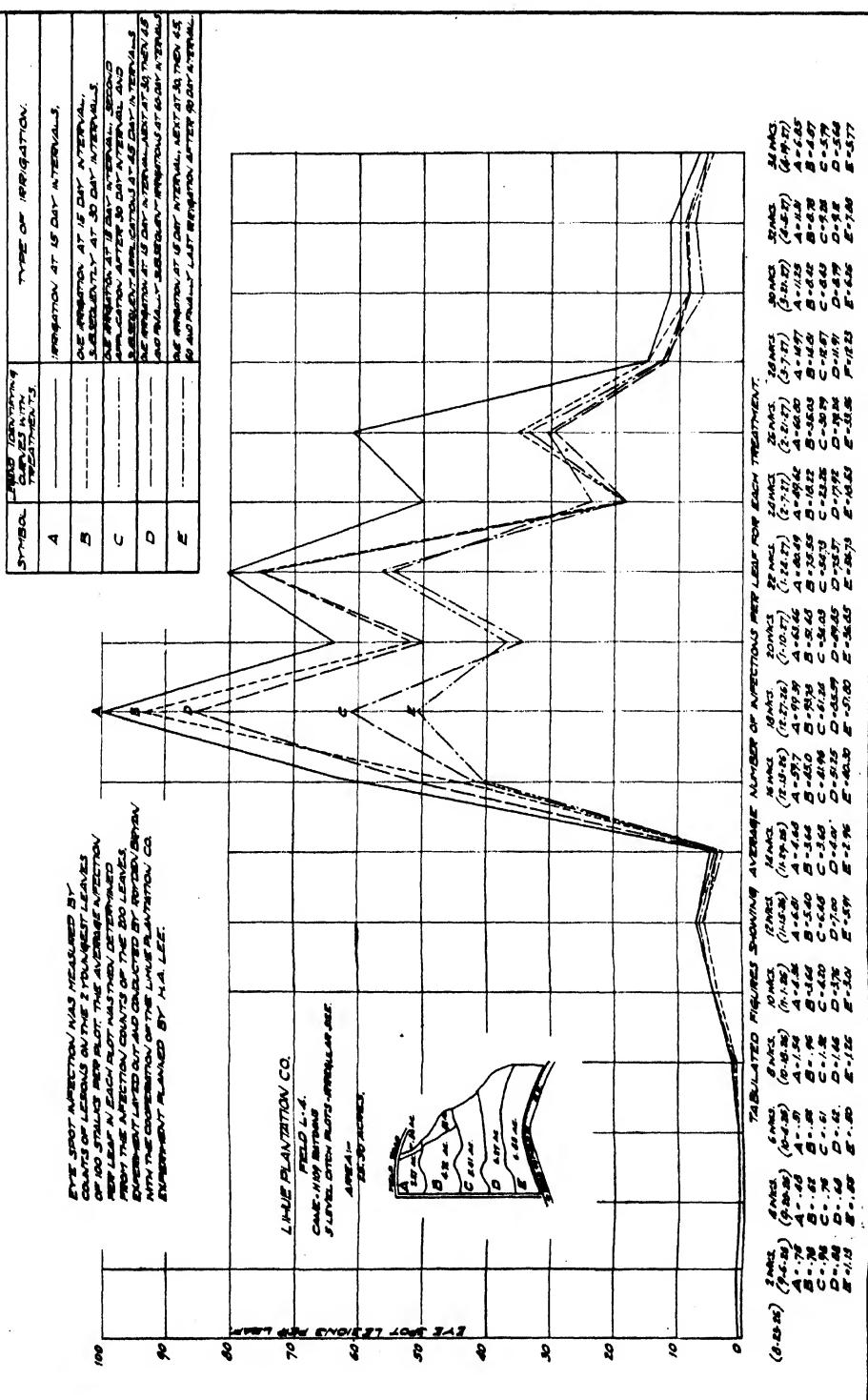
The irrigation treatments were as follows: Plot A received water at 15-day intervals. Plot B received water, first following one 15-day interval, and thereafter at 30-day intervals. Plot C received water first following one 15-day interval, next following one 30-day interval and thereafter at 45-day intervals. Plot D received water first following one 15-day interval, then after a 30-day interval, a 45-day interval and then at 60-day intervals. Plot E received water first following one 15-day interval, then after one 30-day interval, 45-, 60-, and finally a 75-day interval. The attempt was made in these irrigation applications, to avoid the abrupt discontinuance of water, but to gradually taper off the water applications. This is the practice which has been successful against eye spot at the Oahu Sugar Company for several years.

The layout of the experiment is shown in Fig. 1.

The degree of eye spot infection was determined from 200 leaf counts per treatment; the two youngest leaves on 100 stalks per treatment were used to secure the average infection per leaf. The average numbers of infections per leaf throughout the season are charted in Fig. 1.

Growth measurements were taken from 100 stalks per plot and are charted in Fig. 2.

*FIG. I.—THE EFFECT OF THE FREQUENCY OF IRRIGATION APPLICATIONS ON EYE SPOT.*



**FIG. 2:- THE EFFECT ON CANE GROWTH OF DECREASING THE FREQUENCY OF IRRIGATION APPLICATIONS IN EYE SPOT FIELDS**

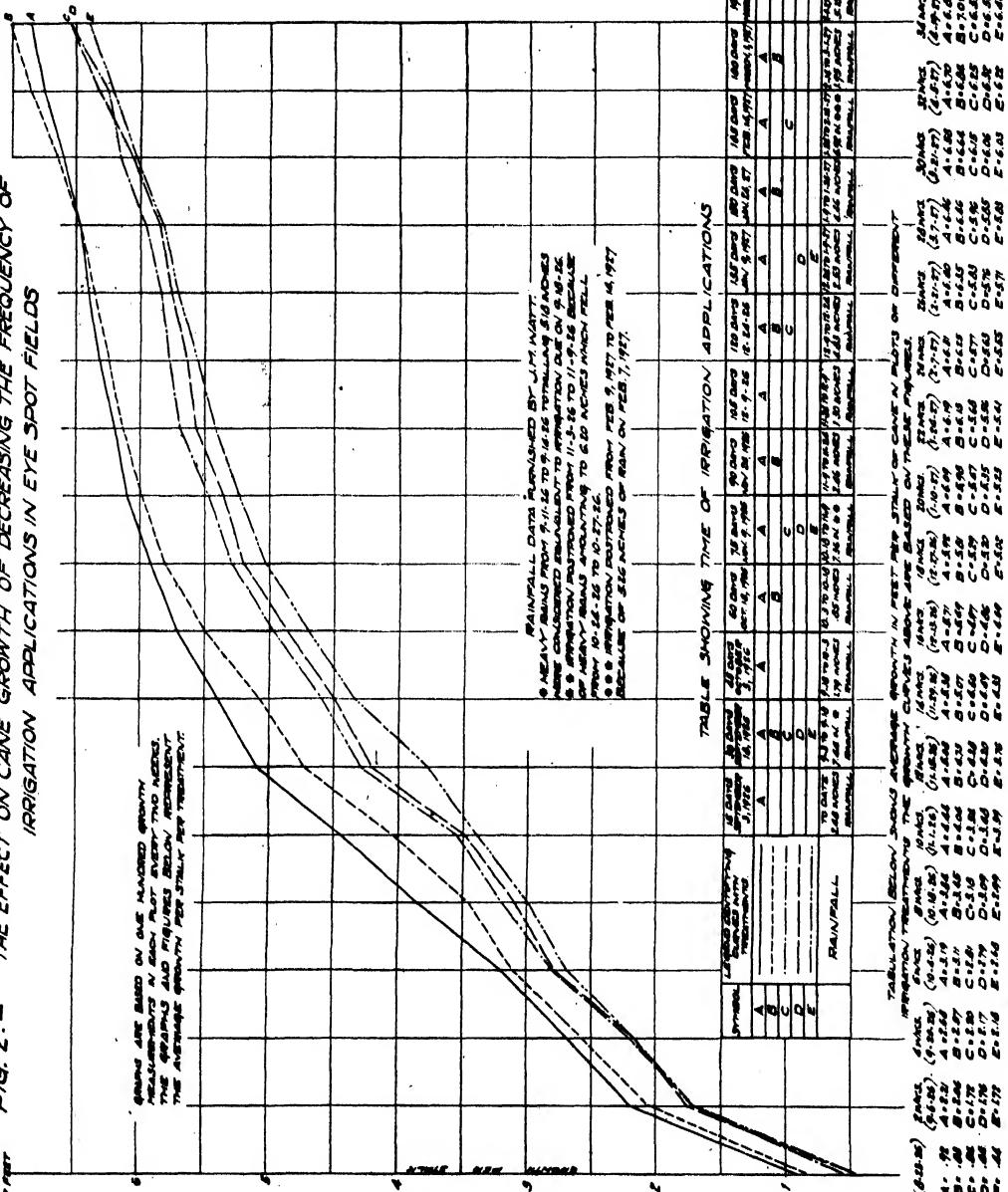


Fig. 2.

From the eye spot graphs in Fig. 1, it can be seen that eye spot infections average less than one per leaf in all plots in the experiment, up to October 4, 1926. Although eye spot then increased gradually, there was no severe increase until November 29. Thereafter there was an abrupt increase in eye spot, reaching the worst peak of infection on December 22, but with two later peaks on January 24, 1927, and February 21. New infections in this field were not severe after March 7.

At all peaks of infection, the cane irrigated throughout the season at 15-day intervals showed the most eye spot. At the first peak of infection the difference between the 15-day interval plots, and the 45-day interval plots amounted to 38 infections per leaf; at the second peak the difference amounted to 26 infections, and at the third peak the difference amounted to 30 infections per leaf. The relative amounts of eye spot infection in the plots with 30-day interval water, 45-, 60- and 75-day interval water were not consistent and the probable explanation is the lack of replications of plots, causing the plots with situations more favorable for infection to show more eye spot in some instances regardless of the frequency of irrigation applications. In general, however, it is evident that the plots with irrigation at greater intervals, showed less eye spot than these plots with frequent irrigations, the lessened eye spot in many cases being the difference between top rot and mere leaf infection.

Our greatest concern, however, was with the rate of growth of the cane under the different irrigation treatments. The plots throughout the early part of the experiment, maintained consistent positions as to growth, the 15-day interval plots exceeding the 30-day plots, which in turn exceeded the 45-day plots, then the 60-day plots, with the least growth in the 75-day interval plots. On November 15 these differences in growth were so great as to indicate that lessening eye spot by decreasing irrigation was at much too large a sacrifice of cane growth.

However, one will recall that the autumn months of 1926 were unusually warm and summer weather existed well into November. With the occurrence of low temperatures in late November and winter months, the growth curve of the cane in the 15-day interval plots flattened off appreciably, while the cane in the less frequently irrigated plots gained appreciably in growth. Thus whereas on November 15 there was a difference of 4.2 inches growth per stalk in favor of the 15-day interval plots as compared with the 30-day plots, on March 19 the 30-day plots had gained on the 15-day plots to such an extent that there was a greater growth of 2.1 inches per stalk in the B plots than in the A plots. Whereas on November 15 the difference in growth between the 15-day interval plots and the 75-day interval plots was 10 inches per stalk (allowing for the difference in growth per stalk in the two plots at the inception of the experiment), on March 19, the cane in the 75-day interval plots had entirely recovered the lost growth per stalk, made previous to November 15.

From an agricultural viewpoint these results are fully as interesting as from the viewpoint of their relation to cane diseases, for they indicate that at low temperatures, and with frequent rainfalls, considerable growth can be lost by over irrigation. Undoubtedly the occurrence or absence of winds constitute a considerable factor in determining the intervals to elapse between irrigation applica-

tions. The results indicate that eye spot can be lessened by increasing the time intervals between irrigation applications, without serious loss in cane growth and even with an increase in cane growth.

It is evident that no rule of thumb can be laid down for the administration of irrigation water in eye spot areas, in the winter months. However, keeping in mind temperatures being recorded at the time, the occurrence of wind, as well as rainfall, the exercise of discretion may be made to increase cane growth, decrease eye spot, and cut down on irrigation charges.

#### SUMMARY

(1) Lessening the frequency of irrigation applications in the winter months materially lessened the severity of eye spot.

(2) Such lessened irrigation decreased cane growth in the warm months, but increased cane growth in the cooler winter months, when abundant rainfall also occurred. Cane with irrigation at 30-day intervals showed 4.2 inches less growth per stalk than the cane with the 15-day interval irrigation on November 15, but showed 2.1 inches more growth per stalk at the end of the experiment on March 19, 1927. Temperature, and possibly the absence of winds, as well as rainfall, seem to be the principal factors in bringing about this increased growth with lessened irrigation applications.

Experiment laid out and conducted by Royden Bryan, with the cooperation of the Lihue Plantation Co., Ltd.

Experiment planned by H. Atherton Lee.

H. A. L.

### The Susceptibility to Eye Spot of H 109 Ratoons as Compared With Plant Cane

It has usually been considered that H 109 ratoons were less susceptible to eye spot than plant cane. It has been difficult to obtain a clear-cut comparison from field observations, however, since slight differences in age of cane, time of fertilizer applications and amounts of irrigation water introduce other variables than the difference between plant and ratoons.

During the past eye spot season, it was possible at the Lihue Plantation Company to make a careful experimental comparison of the susceptibility of plant cane as against ratoons. In a field of recently cut H 109 stubble, 20 plots were laid out, each of approximately 5 rows, each row 35 feet in length; in ten of these 20 plots, the stubble was dug out and H 109 cuttings replanted in place of the stubble. In the ten alternating plots the stubble was allowed to continue growth as first ratoons. The plots thereafter received identical irrigation, fertilizer and cultivation practices. The layout of the experiment is shown in Fig. 1.

**FIG. 1:- THE COMPARATIVE SUSCEPTIBILITY TO EYE SPOT OF H109 PLANT CANE AND RATOONS**

THE INTENSITY OF EYE SPOT INFECTION WAS MEASURED AS FOLLOWS:-  
 TEN STALKS WERE SELECTED IN EACH PLOT, AND AT 2 WEEK  
 INTERVALS, THE EYE SPOT INFECTIONS WERE COUNTED ON THE 2  
 YOUNGEST LEAVES OF EACH OF THESE STALKS. THERE BEING 2 LEAVES  
 PER STALK AND 10 STALKS PER PLOT, IN THE 10 PLOTS OF EACH  
 CHARACTER THERE WOULD BE INFECTION COUNTS ON 200 LEAVES.  
 THE AVERAGE INFECTION PER LEAF FROM THESE COUNTS WAS  
 CHARTED IN THE ACCOMPANYING FIGURE AT DIFFERENT DATES  
 THROUGHOUT THE SEASON.

EXPERIMENT PLANNED BY H. ALLEE AND CONDUCTED BY R. BRYAN.

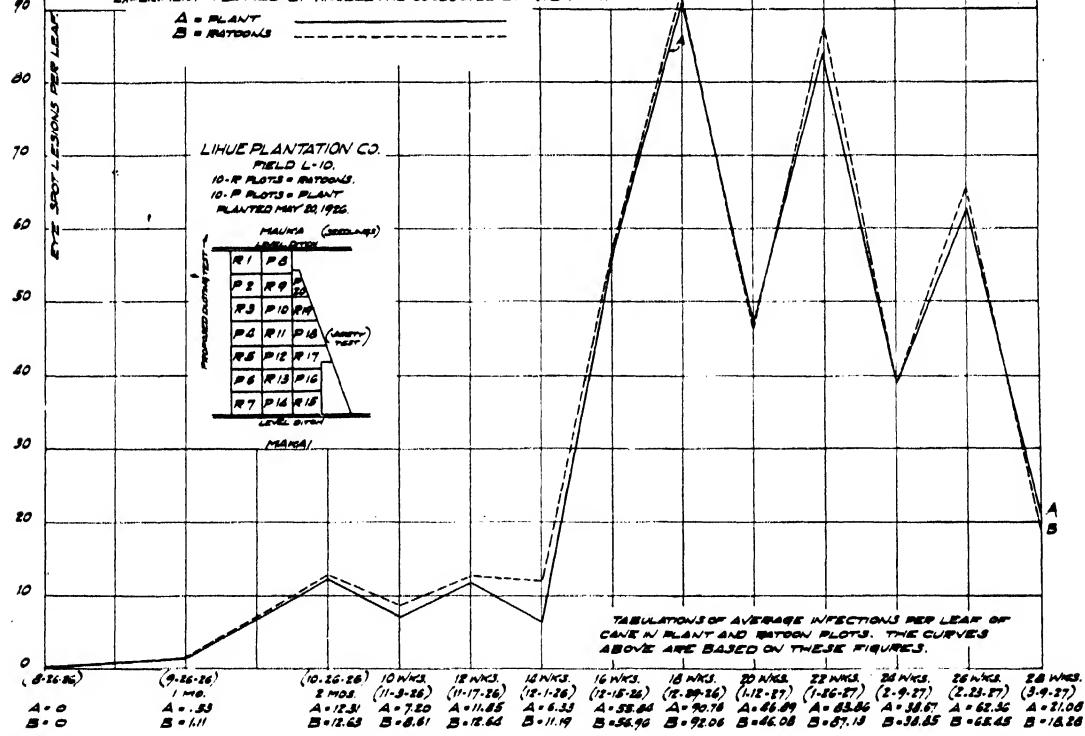
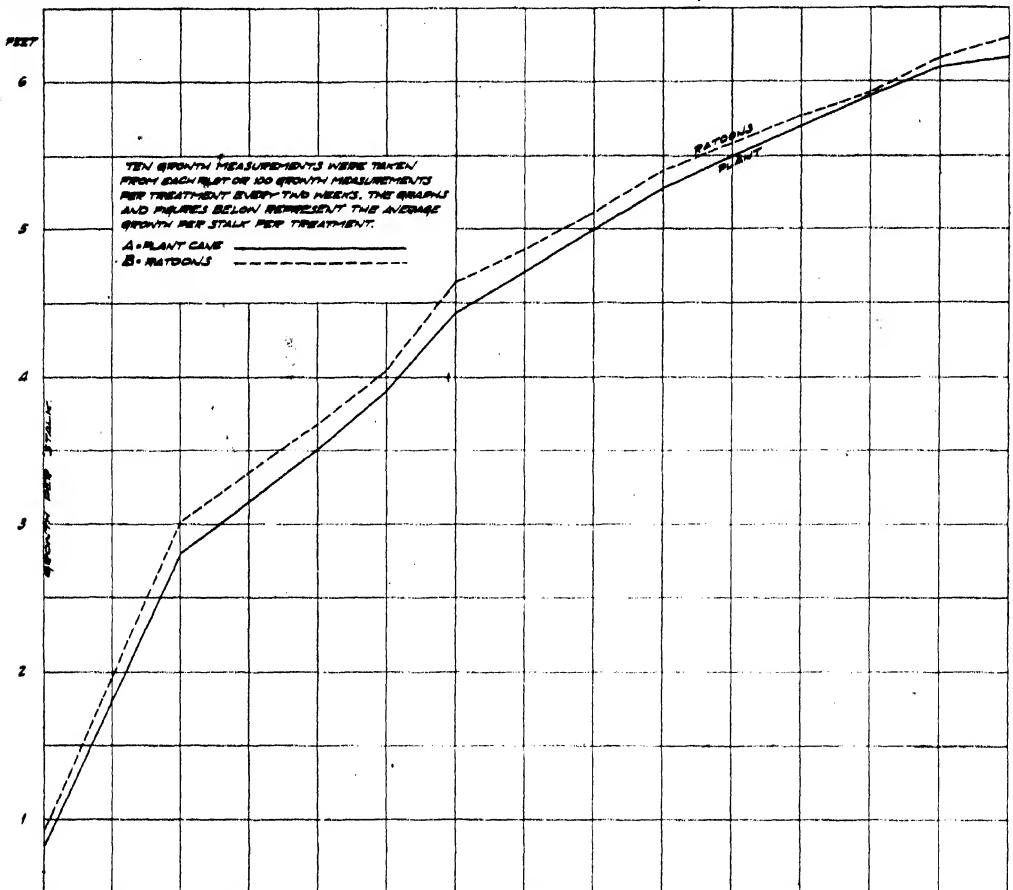


Fig. 1

FIG. 2:- GROWTH MEASUREMENTS OF H/109 PLANT CANE VERSUS RATOONS



TABULATION OF AVERAGE GROWTH IN FEET PER STALK OF CANE IN PLANT AND RATOON PLOTS. THE CURVES ABOVE ARE BASED ON THESE FIGURES.

(8-26-26)	1 MO.	2 MO.S.	10 WKS.	12 WKS.	14 WKS.	16 WKS.	18 WKS.	20 WKS.	22 WKS.	24 WKS.	26 WKS.	28 WKS.
A = .60	(9-26-26)	(10-26-26)	(11-26-26)	(12-26-26)	(13-26-26)	(14-26-26)	(15-26-26)	(16-26-26)	(17-26-26)	(18-26-26)	(19-26-26)	(20-26-26)
B = .67	A + 2.80	A + 3.44	A + 3.90	A + 4.45	A + 4.77	A + 4.98	A + 5.17	A + 5.37	A + 5.60	A + 5.70	A + 5.90	A + 6.09
	B + 3.01	B + 3.67	B + 4.03	B + 4.60	B + 4.86	B + 5.11	B + 5.39	B + 5.57	B + 5.76	B + 5.95	B + 6.16	B + 6.29

Fig. 2.

Counts were made of the numbers of infections on the two youngest leaves of each of ten stalks in each plot. Such stalks were then marked for future identification and subsequent infection counts. Since there were ten replications of each character of plot with ten stalks per plot and two leaves counted per stalk, there were thus 200 leaves upon which infection counts were made and averaged per leaf for the plant cane; an equal number were made for the ratoons. There were ten growth measurements taken in each plot, or 100 growth measurements for each character of plot. Counts of leaf infections and growth measurements were repeated at two-week intervals.

The development of the disease during the winter months is shown in Fig. 1; the longitudinal growth per stalk is shown in Fig. 2.

The graphs in Fig. 1 show that in this field eye spot infections averaged less than 1 per leaf up to September 26, and less than 13 per leaf up to December 1. Thereafter there was then a rapid increase in eye spot. The graphs show the eye spot outbreaks in this field which were typical of many fields on Kauai this year, with not one peak but several recurring with each new occurrence of bad eye spot weather.

The remarkable result in this experiment is the close coherence of the graph for eye spot infection of plant cane with the graph showing infection of the first ratoons.

#### CONCLUSIONS

(1) The conclusion seems quite definite that there are no differences in susceptibility to eye spot between H 109 plant cane and ratoons under identical treatment.

(2) There were no significant differences in longitudinal growth per stalk, between the plant cane and first ratoons.

(3) Aside from their bearing on the susceptibility of plant cane as compared with ratoons, the graphs show the accuracy of such eye spot counts, for eye spot was apparently being counted in plots of identical susceptibility, and the close coherence of the graph for the infection on the ratoons, with the graphs for infection on plant cane, indicates the reliability of this method of measuring eye spot intensity.

Experiment laid out and conducted by Royden Bryan with the cooperation of The Lihue Plantation Company, Limited.

Experiment planned by H. Atherton Lee.

H. A. L.

## Lime\*

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There was a time when most industries thought they had learned all that it was necessary to learn about lime for their particular purposes when they had secured the chemical analysis and the price. Today we are just beginning to appreciate that there are many physical variations in the different limes and their products due to differences in the structure of the original rock, in the methods of burning and in the manner of its slaking or hydration, which will cause wide variations in its adaptability to the many industries now using it as a raw material. The same lime rock, sized and burned in two different ways, both methods being standard practices in various plants in this country, has shown a difference of 40 per cent in the effectiveness of its use in a specific industry, and this in spite of the fact that the high efficiency lime showed by chemical analysis 2 per cent less available oxides.

In many industries lime has not received the study it should have to determine the particular characteristics needed for maximum benefit. This has probably been due to its cheapness, which has doubtless caused many of the consumers to frown upon its importance and to ignore its variations. It is hoped that this symposium will arouse the technical men and the executives in the lime industry and many of the chemical industries using lime to the importance of further investigation, and above all to the need of practical and friendly cooperation between the modern lime manufacturer with his technical staff and those responsible for improving the manufacture and control of practices in the industries using lime.

Lime manufacturing in its simplest form merely involves quarrying lime rock from general strata, passing this material in its crude form through an oven which will stand temperatures up to about 2300° F., and then shoveling this product into a car for shipment.

Lime manufacturing as perfected in some modern plants involves:

- (1) Careful selection of the rock strata that appear in every limestone deposit in order to use for burning only such grades as are specifically suited for the known chemical, building, or agricultural uses for which the lime is to be sold.
- (2) Proper sizing of the rock to give uniformity of burning in the particular type of kiln being used and under the particular method of burning employed.
- (3) Maintenance of steady heat application for uniform and understood periods in order to produce that quality of burnt lime required for the particular trade, and of as nearly uniform quality as modern experience provides in plant control.
- (4) Maintenance of those conditions for hydration which are found to produce the desired characteristics in each lime.
- (5) Thorough and continuous chemical and physical control of all these steps by skilled laboratory supervision.

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\* Extracts from the Lime Symposium presented before the Division of Industrial and Engineering Chemistry, American Chemical Society, Richmond, Virginia, April 11-16, 1927, as published in the *Industrial and Engineering Chemistry*, Vol. 19, No. 5.

Lime manufacturing has become a highly specialized chemical industry, though many do not yet recognize this fact. The methods still pursued in many quarters where the highest grade chemical limes should be manufactured, and the lack of understanding and specifications on the part of many users give evidence of this (1).

Calcination is the most important process in the manufacture of lime. Much progress has been made in overcoming the crudities of the early lime kilns. Increased kiln efficiency has been brought about in several ways as follows:

The shape and sizes of kilns have been modified to accommodate a large tonnage of stone, and to give maximum draft with a minimum of waste heat; also coolers have been so designed that the heat of the burned lime is largely conserved.

The better types of modern kilns are so insulated that there is little heat loss through the shell.

The type of fuel to be used, the arrangement of fire boxes, the time and manner of firing and methods of forced or induced draft, have been studied, and many improvements have been worked out.

Both steam and carbon dioxide, introduced beneath the grates, are employed to control draft and temperature in the fuel bed.

One of the most remarkable developments in the lime industry is the great increase in the manufacture of hydrated lime. From 30 plants producing 120,000 tons in 1906, this branch has grown to 134 plants producing over 1,500,000 tons in 1925. Although used chiefly in the building trades, it also finds wide use in agriculture and for chemical applications. Hydrated lime prepared at the lime plant is advantageous to the user, because with the employment of special equipment under exact control it is more completely hydrated, of greater purity, and in better physical condition than can usually be attained by the cruder hydration methods commonly employed at points of consumption.

From a few well-known uses that could be counted on the fingers of one hand, the uses of lime have so multiplied that they may now be numbered in the hundreds. When lime is applied to various highly specialized uses it is natural that the required properties will vary. This has led to a broad study of the specific requirements of lime for various uses, and to the establishment of fixed standards. The American Society for Testing Materials, the Bureau of Standards, and the National Lime Association have devoted much study to such problems and many specifications are now available.

As a consequence of the exacting requirements much study has been devoted to the properties of lime in their relation to the original limestone, to temperature and time of burning, effects of impurities, calcination equipment, and methods of hydration. Naturally, these two lines of inquiry, the development of specifications and the broader knowledge of the properties of lime, go hand in hand, for the one outlines the qualities desired for given uses and the other determines the methods of selection and manufacture that must be pursued to satisfy most fully the requirements of the consuming industries.

A greatly increased knowledge has been gained of the physical and chemical properties of lime through the researches of the Bureau of Standards and the various fellowships established by the National Lime Association.

It is generally recognized today that physical as well as chemical properties of the original limestone may have a profound influence on behavior during calcination, on cost of manufacture, and on the use of the finished lime. Thus, porous limestones and coarsely crystallized limestones tend to break up greatly during the burning process. Porous limestones may contain water in quantities that demand an appreciable amount of heat for removal. Heat readily penetrates dense, non-porous stones, in consequence of which they may be calcined in a shorter period of time than the loose-textured or porous stones. The complexity of lime-burning is increased by the fact that limestones in no two deposits are exactly alike. Just as in a crowd of one thousand human beings no two faces are alike, so the stone of every deposit has its own individuality. Differences in grain size, in texture, in mode of crystallization, in hardness, in porosity, density, color, or impurities all have their influence in some degree, and thus a new lime-burning enterprise is always experimental in its early stages.

It is well known also that the method of manufacture has a profound influence on the character of the lime produced. Lime manufactured in the rotary kiln is totally different from lime made of the same stone in a shaft kiln. It has been found that limestone calcined in a sintering machine in the short period of 30 to 40 minutes gives a lime which hydrates with extreme rapidity (2).

Liming the soil is recognized as necessary in crop production over vast areas of the humid region. There has been much investigation of the various phases of the liming problem. An important issue centers around the rate of soil treatment. Just how efficient is lime when applied in graduated rates?

According to Truog, the intake of food lime (calcium) by plants appears to be conditional upon the reaction of the soil solution. Whenever the soil solution becomes more acid than the sap of the plant, the crop takes in its food calcium with difficulty. Each kind of crop plant possesses an intrinsic sap acidity. Some, notably alfalfa, are characterized by a weak acidity while others are strongly acid.

The purpose of liming a so-called acid soil is to reduce its reaction to a point milder than the internal acidity of the crop plant to be grown. On a soil of given reaction the magnitude of change necessary to meet the requirement of a specific crop, depending on its sap reaction, may be small or even nil. For another crop, one of mild sap acidity, the relative range could be wide. For the one little lime is needed, for the other much may be necessary to shift the reaction to the point affording the preferred ease and rapidity of lime intake by the plant.

For no farm crop is it necessary to lime a soil to the point of neutrality. All crop plants grow successfully on the acid side of the neutral point. A wide difference in preference is noted, however. Alfalfa and sweet clover exhibit difficulty when the soil reaction falls below 6.5 pH. A drop of less than one pH below this level proves extremely injurious. The purpose of adding liming material to the soil is therefore to raise the reaction toward the preference of the crop (3).

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(1) From a paper by Charles Warner.

(2) From a paper by Oliver Bowles.

(3) From a paper by John A. Slipper.

## Watch the Bottom Blow-off on Your Boiler!\*

BY F. A. PAGE

Only too often is this very important appurtenance of a steam boiler neglected, very little care and attention being given to it, as its importance and usefulness is not understood by the average attendant. Instead of being used to insure the safe and proper operation of the boiler, it is allowed to become inoperative and thus a source of danger to both the attendant and all in the vicinity.

From reports of inspection one can readily see that this appurtenance is the most neglected and abused of all the different appliances on a boiler and has caused many accidents, both fatal and otherwise.

To enumerate all the different causes of blow-off failures on record would be too voluminous, but the principal causes appear to be as follows:

1. Allowing the blow-off pipe to become clogged with mud or scale, and also to be exposed to the products of combustion. This causes overheating, oxidizing, rupture, or total disintegration of the metal in the pipe, and results in a sudden release of hot water under boiler pressure;
2. Improper and neglected fittings are another source of danger. Common service cocks, such as are used in water service, having neither yoke nor gland to hold plug in place, have been the cause of many accidents in the past. The cohesion of the bottom nut and washer caused the bottom stud to be twisted off and allowed the plug to be blown out of the body by the boiler pressure;
3. Broken blow-off pipe and fittings, from either too rapid opening of valves or cocks (producing shocks), or by the indiscriminate use of long wrenches on plug cocks breaking the pipe or fittings while attempting to open the valves or cocks.

Summing up the principal causes of failures, one finds that a number of factors are more or less responsible for the accidents from this source, the most important ones appearing to be:

1. Allowing the blow-off pipe to be exposed to the products of combustion for too long periods of time;
2. Allowing pipe to become clogged;
3. The use of improper materials in pipes and fittings;
4. Improper installation of pipe;
5. Installation of valves or cocks unfit for the purpose;
6. Thoughtlessness or carelessness in operating.

\* From *California Safety News*, March, 1926, Vol. 10, No. 1.

As a guide in the correction of these faults, the following requirements should be complied with:

1. Blow-off pipes and fittings should not be exposed to the products of combustion but should be shielded from such contact; whether exposed or not, such pipes and fittings should be renewed at regular intervals as conditions of service and pressure may require;
2. Blow-off should be operated often, to insure against clogging, or some circulating device installed that will keep mud and scale from settling in the pipe;
3. Only steel pipe and fittings should be used of a weight to meet the requirements of the 1924 Edition of the A. S. M. E. Boiler Construction Code;
4. The installation of the blow-off should be given as much thought and done with the same painstaking care as the installation of the main steam outlet piping;
5. Quick opening valves or cocks should not be installed in the blow-offs of boilers carrying high pressure. The 1924 Edition of the A. S. M. E. Boiler Construction Code calls for slow opening valves;
6. Books could be written on the subject "Human Equation." Ever since man has been and as long as man will be, the thoughtless and the careless have been and will be. But let us not become discouraged. We will be able to arouse the thoughtless and make the careless more careful.

The opening of a blow-off valve or cock should be done with deliberation—slowly and steadily—first to reduce the shock produced by bringing the water in the boiler in motion, and then to give warning in case someone be near the outlet.

The valves and cocks should always be kept in good working condition, so as to assure their operation with ease and safety. It is also very important that the end pipe outside of the valve or cocks be so secured as to prevent any great amount of movement when blow-off is opened.

If two or more boilers have their blow-off connected into a common line, the operator must make sure that blow-off valves on the rest of boilers are closed tight (whether boilers be empty or under pressure), before attempting to open any blow-off valve or cock.

Never use a hicky (club) on valves or long wrenches on plug cocks when opening, while the pressure is on.

The next time you find the valve or plug in cock stuck, and you are tempted to use a hicky or a long wrench, *stop, brother, don't do it!* Think of the possible consequences. Think of those depending on you. If *you* have no dependents, think of those near by who may have. Don't let your friends say, "Too bad. Jim was a fine fellow, but just a little bit careless."

[W. E. S.]

## Sugar Prices

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**96° Centrifugals for the Period  
March 16, 1927, to June 14, 1927**

Date	Per Pound	Per Ton	Remarks
March 16, 1927.....	4.74¢	\$94.80	Cubas.
" 17 .....	4.90	98.00	Cubas.
" 18 .....	4.68	93.60	Porto Ricos.
" 21 .....	4.695	93.90	Porto Ricos, 4.68; Cubas, 4.71.
" 22 .....	4.68	93.60	Porto Ricos.
" 23 .....	4.71	94.20	Porto Ricos.
" 24 .....	4.68	93.60	Porto Ricos.
" 28 .....	4.65	93.00	Cubas.
April 4 .....	4.595	91.90	Porto Ricos, 4.61; Cubas, 4.58.
" 5 .....	4.52	90.40	Philippines.
" 6 .....	4.535	90.70	Porto Ricos, 4.55, 4.52.
" 7 .....	4.6133	92.27	Cubas, 4.58, 4.65; Porto Ricos, 4.61.
" 8 .....	4.63	92.60	Cubas, 4.61; Philippines, 4.65.
" 11 .....	4.71	94.20	Cubas.
" 12 .....	4.755	95.10	Cubas, 4.74; Porto Ricos, 4.77.
" 14 .....	4.80	96.00	Cubas, 4.77, 4.83; Porto Ricos, 4.80.
" 18 .....	4.83	96.60	Cubas.
" 19 .....	4.77	95.40	Philippines.
" 20 .....	4.865	97.30	Porto Ricos, 4.83; Philippines, 4.90.
" 21 .....	4.90	98.00	Porto Ricos.
" 25 .....	4.86	97.20	Porto Ricos.
" 27 .....	4.83	96.60	Philippines.
" 28 .....	4.77	95.40	Cubas.
May 2 .....	4.74	94.80	Cubas.
" 5 .....	4.77	95.40	Cubas.
" 7 .....	4.815	96.30	Cubas, 4.80, 4.83.
" 10 .....	4.83	96.60	Cubas.
" 11 .....	4.865	97.30	Porto Ricos, 4.83, 4.86; Cubas, 4.87, 4.90.
" 12 .....	4.90	98.00	Porto Ricos.
" 13 .....	4.87	97.40	Cubas.
" 14 .....	4.83	96.60	Porto Ricos.
" 19 .....	4.80	96.00	Cubas.
" 20 .....	4.815	96.30	Cubas, 4.80; Philippines, 4.83.
" 21 .....	4.87	97.40	Cubas.
" 25 .....	4.815	96.30	Philippines, 4.80, 4.83.
" 26 .....	4.8533	97.07	Porto Ricos, 4.83, 4.86; Cubas, 4.87.
June 1 .....	4.815	96.30	Cubas, 4.80; Porto Ricos, 4.83.
" 3 .....	4.77	95.40	Cubas.
" 6 .....	4.74	94.80	Cubas.
" 7 .....	4.65	93.00	Cubas.
" 9 .....	4.58	91.60	Porto Ricos, 4.61, 4.55.
" 14 .....	4.52	90.40	Porto Ricos.



# THE HAWAIIAN PLANTERS' RECORD

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OCTOBER, 1927

Number 4

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## Forestry on Oahu\*

By H. L. LYON

The first and most difficult step in carrying out adequate forestry work on Oahu has been accomplished. This was the securing for forest reserves of the watershed areas on Oahu which should be covered with forests. The adequate protection of these areas from invasion by cattle is assured and will be an accomplished fact within the next few months. After the cattle are removed from the reserves we shall still have one serious animal pest to contend with. Wild pigs are extremely numerous in the Koolau Mountains. They stay well back in the valleys and in fact seem to be most numerous and most destructive at the very heads of the valleys. They are clearing out the undergrowth and preparing the soil to receive Hilo grass and staghorn fern. It is imperative that we make strenuous efforts to eliminate the pigs from our forests. It is generally held that the only effective method to accomplish this result will be to hunt them down with dogs. This will require the persistent efforts of numerous hunters, and to make their work effective they must be paid wages in addition to the meat which they are able to bring out. Men hunting pigs only for sport or for meat will never complete a campaign of extermination. The issuing of hunting permits to all those requesting them will not go very far towards accomplishing the desired result, and a very serious objection to free-for-all pig hunting within the reserves is the danger that irresponsible hunters will start forest fires. We believe that a well conducted campaign of poisoning would be the most successful method of handling the pig problem. There are several effective poisons which could be used safely in such a campaign; their distribution on the watersheds in no way jeopardizing the lives of the people and stock drinking the drainage water therefrom.

\* Communicated to the Forestry Committee, A. F. Judd, chairman, devising a forestry program for Oahu.

There can be no doubt that the remnant of native forest on the watersheds of Oahu is doomed to pass out of existence in the next hundred years if our only efforts are such as are designed to protect it. The old trees are dying one by one and there are very few young native trees coming on to take their places. Hilo grass and uluhi quickly take over and hold each new opening made by the fall of a veteran tree, and if nothing intervenes our watersheds will eventually be covered with these and other pernicious weeds to the exclusion of all tree growth.

A third introduced plant which now threatens to become as troublesome in the forests on Oahu as is either Hilo grass or uluhi is the so-called Para grass, *Panicum barbinode*. The extensive use of this plant on the pineapple plantations for fodder and green soiling purposes is responsible for its wide distribution along the border of our forests and it has already penetrated to considerable depths at many points. With its long runners it climbs over young trees and smothers them down quite as effectually as does the uluhi, and the thick mat of coarse, tangled stems with which it covers the soil prevents the growth of seedling trees.

#### FIREBREAKS

The staghorn fern or uluhi now extends from the margin of the forest to the very summit of the Koolau Mountains, and constitutes, during dry weather, a continuous blanket of inflammable material covering the most important watershed on Oahu. Should a fire get well started in this uluhi, it is certain to spread over a very large area before we can get it under control and it is quite possible that it would sweep the entire length of the Koolau Range. It is imperative, therefore, that we take steps to divide this blanket up into sections by trails along which we can meet and stop any fire that may get started. These trails should properly run along some of the ridges extending from the edge of the forest to the summit of the backbone ridge. We should endeavor to make these trails permanent fire-breaks by creating along them a mesophytic, fireproof forest which will forever hold back the uluhi.

#### REFORESTATION

The reforestation of our watersheds requires operations of two distinct categories. First, the reforestation of denuded lands, and second the rejuvenation of existing forests.

It has been often stated that the proper method of procedure to bring about the reforestation of our denuded lands would be to plant small groves of trees at intervals and then wait for the intervening spaces to be planted up by the natural spread of the trees previously planted. Such a process would require a very long period for the successful accomplishment of the desired result. A large part of the denuded areas is covered with Hilo grass, uluhi, lantana and guava, and these hardy plants are going to vigorously contest the progress of any trees which we may pit against them. The reforestation of these denuded areas is of such great economic importance to us that I believe it should be accomplished by

the speediest and surest methods available, and these are the actual planting out of trees at regular intervals over all the denuded lands.

We are most vitally interested in the watersheds included in the Ewa, Kawai-loa, Kahuku, Kaipapau, Mokuleia and Honouliuli forest reserves. A careful survey by Mr. McEldowney shows that there are approximately 15,000 acres of denuded land within these reserves which should be reforested. Planting on the average 100 trees to the acre, 1,500,000 trees will be required to cover this area. A logical program would call for the planting of these trees in 10 years or at the rate of 150,000 trees a year. It would hardly be advisable to exceed this quota, at least, not during the first 5 years or until we are better able to judge of the success we are attaining in building up an effective water-conserving forest formation. As a general rule, we think these trees should not be planted closer than 20 feet apart each way. Trees so planted will eventually shade out the grass and uluhi and create conditions suitable for the germination of the seeds which they will produce. The general practice which we would advocate is the cutting of trails through the grass and scrub and the planting of trees at intervals along these trails. On areas covered by uluhi it is sometimes possible to isolate large blocks of the fern with firebreaks and then burn off these isolated blocks. The uluhi closes in very slowly on trails which have been cut through it and trees planted along such trails need attention two or three times only before they are above the fern.

Given trees of a suitable size for planting we can clear out trails, dig holes and plant these trees on denuded lands at an average cost of 10 cents per tree. We have averaged as low as 6 cents on some areas, but clearing of lantana and uluhi and difficulties of transportation have run the costs up rapidly on other areas. Our figures on the cost of caring for trees after planting and until they are able to shift for themselves are less satisfactory, but we are sure that this work can be accomplished at a cost not exceeding 3 cents per tree.

#### REJUVENATION OF EXISTING FORESTS

As previously stated, it is obvious that the native trees on Oahu are rapidly passing out of existence and that they are showing no signs of recovering our watersheds through the establishment and growth of young seedlings of their own species. Hilo grass and uluhi have spread throughout the forests, covering the forest floor and effectually checking the reproduction of the native plants. What we really need to do under the circumstances is to introduce into our waning forests some tree or trees that will rapidly replace the declining native trees. Unfortunately we have at hand no tree, either native or introduced, the seedlings of which can develop unaided on soil covered with Hilo grass or uluhi. It is impracticable to attempt to cut trails throughout our existing forests and set out trees along these trails. What we must have are trees that will spread through the forests in their present condition and give us a covering equal to or superior to the native forests. Several species of figs already introduced promise to fulfill these requirements, for their seeds, carried about by birds, germinate on the branches

of other trees or on stumps and fallen logs and from such elevated positions the seedlings send down their roots to the soil and eventually establish themselves as independent trees. Because of the perching habit of their seedlings these trees can spread through our declining forests despite the prevalence of Hilo grass and uluhi on the forest floor. We should therefore continue to plant figs in small groups at intervals on our watersheds and in the course of time the resulting trees will supply the seed to bring about natural rejuvenation of our declining rain forests. We now have two species of figs on this island which are producing viable seed. These are both good trees but the evidence obtained in our various arbo-retums indicates that other species would prove more efficacious under our conditions. Among the most promising species are: *Ficus retusa*, *F. nota*, *F. glomerata*, *F. altissima*, *F. elastica*, and *F. bengalensis*. We believe that efforts should be made as soon as possible to introduce the wasps associated with each of these species in order that our local trees may produce viable seed and at once become factors in the rejuvenation of our rain forests.

#### THE ULUHI PROBLEM

A few years ago the writer called attention to the serious obstacle which the uluhi presented to any program of reforestation. He has also pointed out the serious fire menace which it creates in our forests. He is probably responsible, therefore, for the impression that has gained credence in some quarters that we can not have new forests as long as we have uluhi. This is far from the truth. At present the uluhi is probably the most serious obstacle to cheap reforestation on Oahu, but if we did not have uluhi we might easily have something else quite as bad or even worse, and if we could remove the uluhi completely at this time it is quite possible that Para grass would offer even a more serious problem at the end of another 5 or 10 years. The only way to successfully control a pestiferous plant of this sort is to pit against it some desirable plant or plants that can successfully fight it and take the ground away from it. The difficulty at the present time is that we are not pitting against the uluhi plants that can cope with the particular tactics which it employs.

Uluhi can be successfully suppressed by shading out with plants of greater stature. A dense forest formation could move slowly into territory occupied by uluhi by shading the fern out along the margin of the forest and thus making the ground suitable for young trees and shrubs that naturally spring up in the shade. Uluhi can be successfully pushed back by plants which will send runners underneath it from which shoots will grow up through its blanket and overtop it in the manner characteristic of certain bamboos. We have already successfully introduced several plants which produce root suckers. These root suckers spring up at intervals progressing outward from the parent plant in all directions and invading the surrounding country like a marching army. Another type of plant which is successfully combating the spread of uluhi is one which climbs over its blanket producing a mass of vegetation above it and thus smothering it down. The common aroid, *Pothos aureus*, is proving very effective in a contest of this

sort. It is a vigorous growing, fleshy vine producing very large leaves. It can grow in full sunlight, but it prefers partial shade. It burrows through the blanket of uluhi and overtops it with a mass of heavy, dense foliage. It seems to delight in the conditions which the uluhi affords. *Pothos aureus* has never been known to produce flowers and seeds but it is easily propagated from cuttings and it will be a simple matter to distribute these in an uluhi-infested area.

The success attained with *Pothos aureus* has encouraged us to seek other vines that might prove equally efficacious in combating uluhi. Vines are an essential element in a tropical rain forest and any vine that we may introduce for combating the uluhi will remain as a desirable element in the forest formations which we hope to build.

To recapitulate, I would say that the most serious obstacles to forestry work on Oahu have already been overcome. We can now formulate and execute a program for the conservation of existing forests and the creation of new forests. This program should provide for:

1. Elimination of pigs.
  2. Creation of firebreak trails.
  3. Planting up of denuded lands.
  4. Rejuvenation of existing forests by introduction of figs and other plants that can spread through these forests in spite of the Hilo grass and uluhi which now control the forest floor.
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## The Application of the Principles of Base Replacement to Reservoir Treatment

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By G. R. STEWART AND F. E. HANCE

### FOREWORD

In a recent conversation with Mr. Greene, manager of the Oahu Sugar Company, we learned that he had considered for some time the employment of a chemical treatment in securing increased impermeability to the natural inside reservoir surface.

Early in 1927, Mr. Bomonti, chemist of the sugar technology department, brought into this laboratory a sample of clay which he had obtained from Mr. Robbins, chemist of the Oahu Sugar Company, at Waipahu. The suggestion was made by Mr. Bomonti that an experiment on the flocculation properties of the clay would be of interest in connection with the possibilities of employing the chemically treated material for lining reservoirs. Independently of the work subsequently carried out in this laboratory, Mr. Robbins has been experimenting with rather extensive chemical clay treatments in its practical reservoir application.

He has conducted numerous laboratory experiments of a quantitative nature in determining the most suitable clay and chemicals to employ in actual reservoir practice.

We wish to make this contribution, therefore, a supplementary one to the pioneer investigations instituted at the plantation of the Oahu Sugar Company.

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In studies conducted by soil investigators in various parts of the world, the effects of the salts of sodium on the physical properties of soils have been given considerable attention.

The presence of a high concentration of sodium over other bases, particularly calcium, will produce in a clay soil a condition of compact impermeability, if it later receives a heavy irrigation of fresh water.

Hissink<sup>3</sup> in writing of the effects of ocean flooding on Dutch kwelder soils remarks that as a result of the inundation, the percentage of exchangeable sodium increases and then the soil, when irrigated, will not allow water to readily percolate through.

In a discussion of the reclamations of the salt-injured soils of Arizona, McGeorge<sup>5</sup> points out the futility of any attempt to wash out the large amounts of sodium salts because by so doing the soil "gradually becomes deflocculated and impermeable to water."

The observations of Kelley<sup>4</sup> from his researches on the semi-arid regions of California lead him to state: "One of the important effects produced by the substitution of sodium for the divalent bases is that the granular structure of the clay material becomes broken down with the resulting development of extreme impermeability."

Our experiences in Hawaii<sup>1 and 2</sup> include an additional base magnesium which imparts equal or more impermeable qualities to some of our clay-like soils than does the more common base sodium.

We shall not attempt to go into the theoretical side of the subject in this discussion. That matter has been covered in other contributions with references which appear in the text of this paper. The application of the principle of base replacement can very readily be demonstrated by anyone having access to a glass funnel and a quantity of distilled or high quality tap water. The employment of the principle in sealing a reservoir would suggest itself to one making the experiment as outlined below:

Obtain about one pound of clay-like soil which is known to be sticky, adhesive and impermeable when it is wet. Air dry the soil and powder it as thoroughly as possible by any convenient means.

Place a few ounces of the powdered clay-like soil in a common drinking glass, add about  $\frac{1}{4}$  to  $\frac{1}{2}$  ounce of table salt and enough distilled or good tap water to produce a thin paste. Stir the mixture thoroughly and pour into a funnel, the orifice of which has been covered with a plug of moistened absorbent cotton. Allow the excess of water to drain off. Add additional distilled or pure tap water

to the soil mass in the funnel and allow that to drain out. Repeat the addition to and draining out of successive portions of water several times.

It will be noted that the time required for the passage of subsequent additions of water will rapidly reach an interval of long duration. In some cases the passage of water will practically stop even against a 10- or 12-inch head of water in a long cylinder with a funnel outlet.

The conditions now impressed on the soil are known as "freezing" and will persist for a considerable length of time.

The same results will be obtained to a greater or less extent by following the procedure outlined above with the substitution of magnesium sulphate (epsom salts) for the common or table salts which is there specified.

A comparison of the effect of the two salts would determine the better one to use on a larger scale.

In treating a reservoir which is designed to hold mountain water, we would suggest a laboratory experiment to determine the minimum amount of salt which could be employed to "freeze" a known weight of the clay-like material which is available. A coating of 2 to 8 inches in the reservoir bottom should suffice. Having calculated the relative amounts of clay and salt to employ, the materials should be placed in the empty reservoir. Enough mountain water should be added to produce a heavy paste. A mule-drawn drag would materially assist in incorporating salt and clay.

If the reservoir is now partially filled several times and allowed to stand after each filling until leakage has stopped, or at least slowed down, it is ready for use.

As a final mechanical treatment in the last filling, the operation should be so conducted that a thorough agitation of the clay and water is secured.

This operation will assist in securing a maximum dispersion of the clay colloid. It will also insure the deposition of a superficial coating of impervious material on the sides of the reservoir and thus assist in closing up numerous and small porous outlets.

This treatment would prove of little value in the storage of pump water of high salt content.

We feel, however, that mountain or other water of low salt concentration can be impounded with appreciable savings in leakage by treating the reservoirs as herein described.

#### SUMMARY

This paper deals with a potential process of reservoir sealing by employing the principle of colloid dispersion in clay-like soil lining.

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## Rate of Cane Growth at Various Ages

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By J. A. VERRET AND U. K. DAS

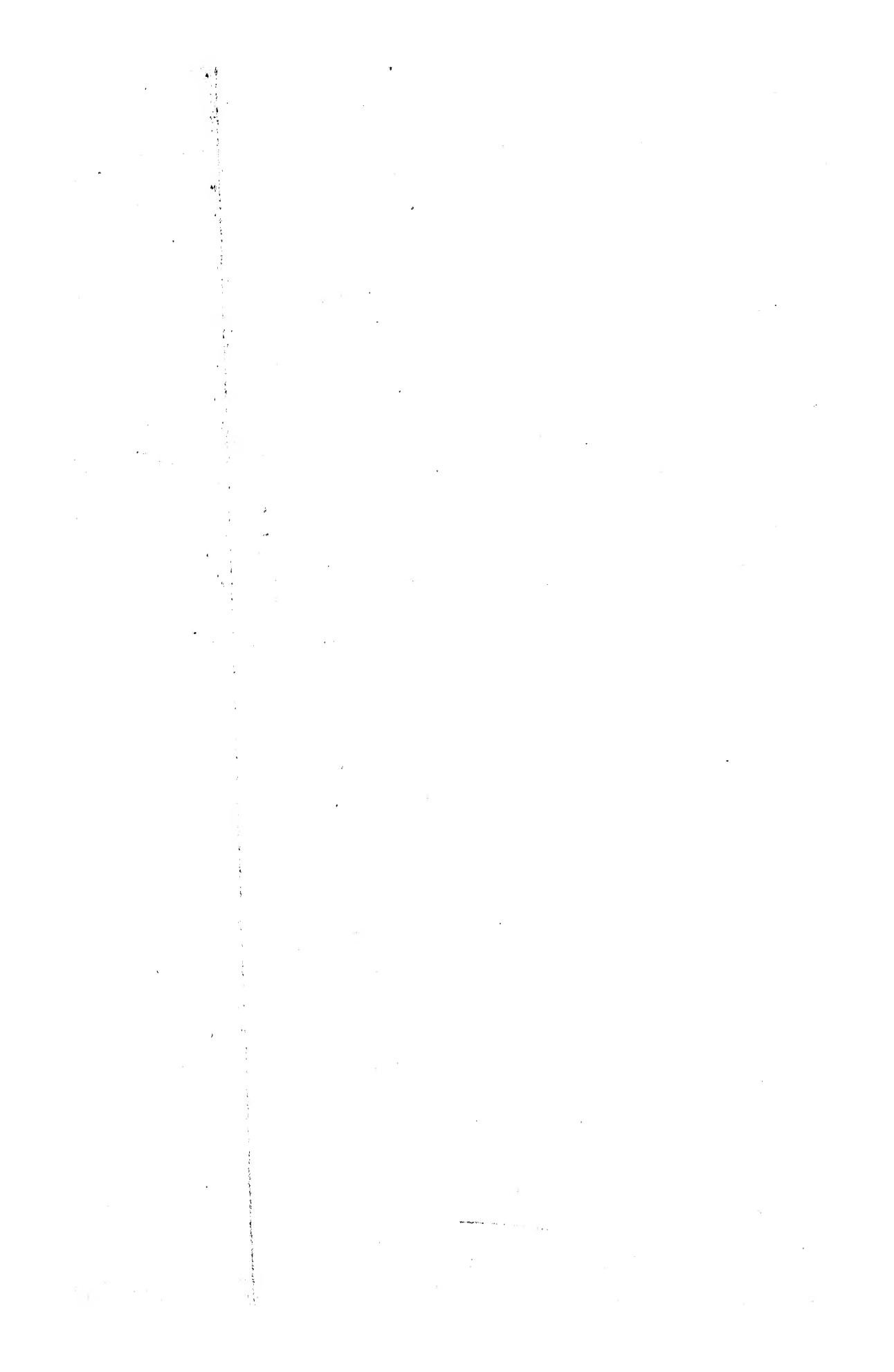
These studies were conducted at Makiki in Honolulu. They were begun in July, 1925. From that time plantings were made every month up to June, 1926. One of the most uniform plots at Makiki was selected for this planting in order to reduce as much as possible the soil variation factor. Moisture conditions were kept at as nearly optimum as could be done. Irrigation was at the rate of 8" for the first four months and then at the rate of 16" per acre per month. In order to keep the plant food factor constant all canes were fertilized every month at the rate of 25 pounds of nitrogen per acre; phosphoric acid and potash were put on at the rate of 15 pounds per acre.

Growth measurements were taken from 20 stalks in each planting. During most of the time measurements were made at two-week intervals, others at four weeks. It was originally intended to allow each planting to grow for two years, but when several cases of gall were detected it was decided to harvest the field. From the experiences gained in this preliminary work, we have now started a larger test at Waipio, where not only will growth measurements be taken but areas will be harvested at various ages. At this time the distribution of the roots will be determined by excavation, and the total plant food in the crop will also be determined.

### SEASON RATE OF GROWTH OF THE SUGAR CANE PLANT

The records of the growth measurements are given in Table 1 and are charted in Fig. 1. Fig. 1 is based on figures given in Table 1A. The growth curve in Fig. 1 is based on cane 6 to 10 months old, inclusive. Cane of these ages only was used in order to eliminate the age factor in the rate of growth. Cane of these ages had the same number of growth measurements made in all months of the year, the others had not. The growth curve given in Fig. 1, therefore, represents, as nearly as we could make it, seasonal variations only.





Temp. Growth  
F° in Feet

MONTHLY GROWTH BASED ON CANE  
6 TO 10 MONTHS OLD INCLUSIVE

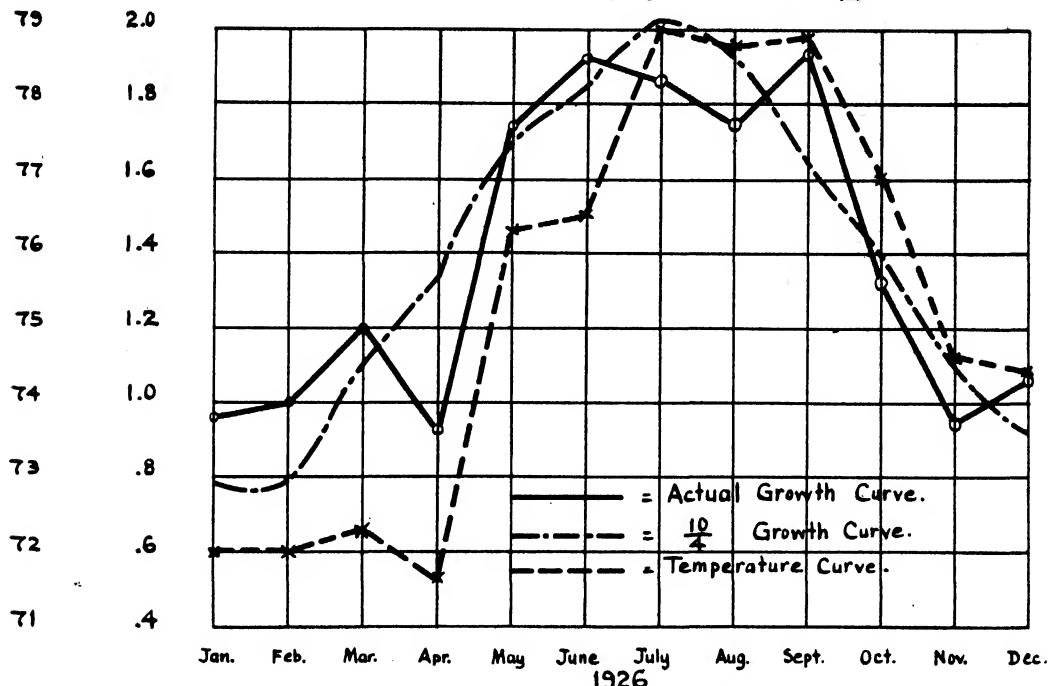


Fig. 1

*The Probable Effect of Wind:* There appears to be a fair degree of correlation between the temperature and the growth curve throughout most of the period. At places, however, there are certain irregularities. The temperature curve does not vary greatly from July to September, but the growth curve goes down in July and August. Our record shows that on July 8, Field 3 at Makiki was cut, and on July 28 most of the cane in the measurement area was stripped high to facilitate taking measurements. Field 3 was on the mauka side and had served as a windbreak up to this time. By cutting Field 3, the cane in Field 2 was exposed to wind. High stripping probably removed some leaves that were still feeding the stalk and at the same time exposed the cane and the cane rows to the action of wind. Recent experiments at this Station have shown that strong wind retards growth by doing damage to the leaves and under certain conditions by increasing evaporation and perhaps by lowering the temperature locally. The fall in the growth curve between July 6 and August 3 may reasonably be attributed to the effects of stripping and sudden exposure to wind.

*The Probable Influence of Daylight:* It will be seen from Fig. 1 that up to about the middle of July, the growth curve leads the temperature curve, but from about the month of September the growth curve lags behind. In other words, an increase in temperature gives a large increase in growth up to the middle of July, but from September, this increase is comparatively smaller for a given rise in temperature. This may be due to decreasing daylight from July on. The beneficial influence of both these factors, namely, temperature and daylight, were

felt at the same time in spring and early summer. But from August on the favorable effects of an increase in temperature are partially undone by the adverse influence of the decrease in the hours of daylight. That is, the favorable temperature has less time in which to exert its influence. When the temperature goes down in autumn the rate of fall is accelerated by decreasing daylight. Experiments at Makiki have shown that, regardless of temperature, cane makes most growth with maximum daylight.

In addition to the above we believe another factor is acting, tending to cause the plant to make less efficient use of temperature in autumn and winter. In practically all plants, spring and summer is the period of natural fast growth, when the plant is putting on volume; as autumn comes, this tendency becomes less and less and the plant tends towards maturity. This is very marked in annuals, but we feel that even a tropical plant such as sugar cane feels these influences to some extent.

If one smoothed out the growth curve given in Fig. 1 in order to more nearly approach the average seasonal variations, a curve would result which resembles the 10-4 curve suggested by Agee in his "Essential Factors of Sugar Production." The dot-dash line in Fig. 1 is a 10-4 curve. Possibly the values shown for the 10-4 curve are too low for the months of June, August and September. The drop in growth in April is accounted for by the low temperatures and rather strong winds. We have already accounted for the dip in July and August.

TABLE 1B  
ELONGATION OF H 109 CANE PER GROWTH DEGREE  
FIELD 2—MAKIKI

Period of Growth—From Time of Planting to March 1, 1927

Cane planted first day of	Length of cane in feet	Total growth de- grees July:Jan. 10-4	Growth in feet per degree	Total growth de- grees July:Jan. 10-2	Growth in feet per degree
1925, July.....	18.73 (to Feb. 1, only)	575	.033	570	.033
August.....	18.00	545	.033	530	.034
September.....	17.72	505	.035	480	.037
October.....	16.72	470	.036	440	.038
November.....	16.23	440	.037	410	.040
December.....	15.83	415	.038	390	.041
1926, January.....	14.15	395	.036	380	.037
February.....	12.85	375	.034	370	.036
March.....	12.52	360	.035	360	.035
April.....	11.85	335	.035	340	.035
May.....	10.63	305	.035	310	.034
June.....	9.03	270	.033	270	.033

In Table 1B we give a study of the rate of cane growth on the basis of Agee's "growth month" method.

In the first column we give the total elongation of the canes planted each month in the year. In the second and fourth columns you find the growth degrees represented by the age of the cane, for both the 10-2 and the 10-4 ratio. The 10-2 ratio means that a unit of growth time in July is given 5 times the value of the same period in January; for the 10-4 ratio it has two and one-half times the value.

In columns three and five we list the growth in feet per degree for the various plantings.

Under ideal conditions, with a perfect ratio, this growth should be the same, no matter when the cane was planted.

Under actual conditions from July, 1925, to July, 1926, we find that this ideal was somewhat closely approached by the 10-4 ratio. The greatest variation was between July, 1925, and December, 1925, where the difference was .005 foot per growth degree or about 13 per cent.

For conditions as they were during this period the values given for the winter months are somewhat too low.

#### RATE OF SUGAR CANE GROWTH AT VARIOUS AGES

We give the rate of growth of sugar cane at various ages in Table 2 and present the data in graphic form in Fig. 2. These data are preliminary only and further work may introduce some modifications in the growth curve as given, but we feel that the general form of this curve is essentially correct. It may be that the more extensive work will show that the rate of drop in the curve with increasing age will not be quite as rapid as that given in our curve.

THE RATE OF GROWTH PER MONTH OF CANE AT DIFFERENT AGES  
(Data From Table 2)  
CANE - H109 MAKIKI FIELD 2.

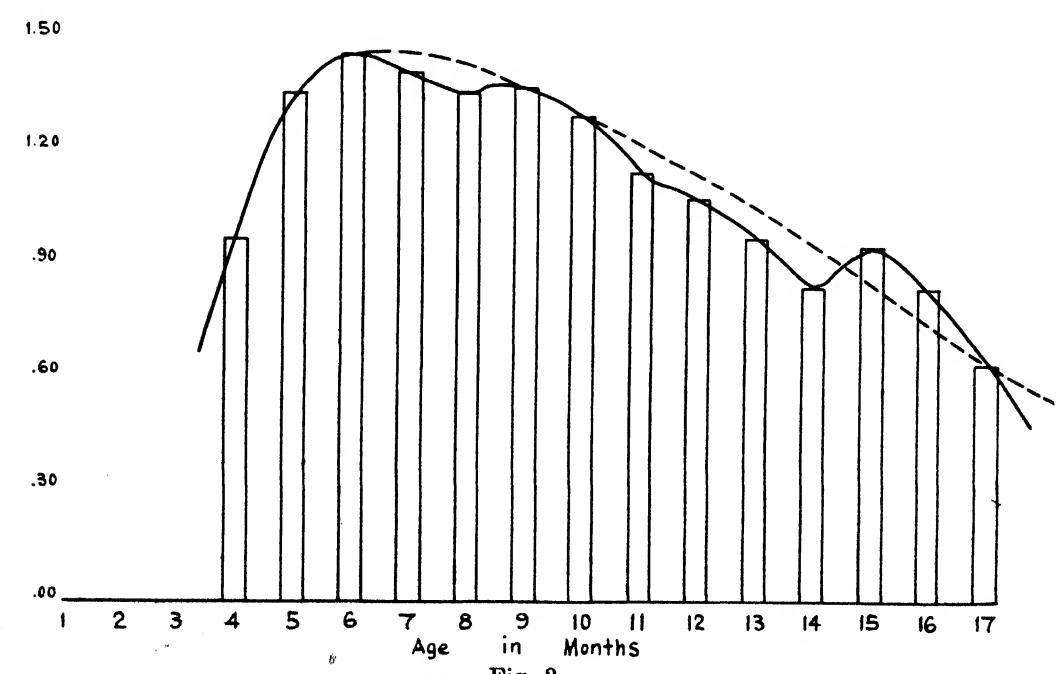


Fig. 2

TABLE 2  
GIVING THE GROWTH (IN FEET) AT VARIOUS AGES OF CANE PLANTED IN THE DIFFERENT MONTHS OF THE YEAR

Planted	Age 4 Months	5	6	7	8	9	10	11	12	13	14	15	16	17
July, 1925.....	.93	1.01	1.27	1.06	.85	1.10	.95	1.59	1.64	1.45	1.05	1.62	1.40	.70
August.....	.87	1.01	1.11	1.06	1.18	.82	1.57	1.64	1.52	1.26	1.56	1.30	.56	.40
September.....	.91	1.08	1.17	1.36	.97	1.67	1.74	1.55	1.58	1.56	.87	.60	.40	.38
October.....	.85	.94	1.33	.95	1.61	1.80	1.80	1.60	1.56	1.09	.58	.43	.42	.36
November.....	.45	.94	.87	1.93	1.92	1.91	1.94	1.68	1.30	.70	.47	.51	.43	.55
December.....	.72	.83	1.89	1.92	1.84	2.05	2.07	1.24	.70	.53	.37	.53	.73	.42
January, 1926.....	.49	1.83	2.10	1.91	1.34	1.74	1.15	.80	.53	.62	.57	.83	.55	.80
February.....	1.18	1.76	1.81	1.65	2.10	1.33	.92	.53	.50	.38	.73	.63	1.05	.89
March.....	1.35	1.78	1.68	1.83	1.64	.88	.74	.69	.62	.84	.56	1.20	1.16	.87
April.....	1.32	1.79	1.92	1.24	.86	1.05	.71	.70	.93	.64	1.06	1.32	1.13	.80
May.....	1.18	1.91	1.24	.93	1.12	.99	.85	.99	.71	1.22	1.11	1.29	1.05	.89
June.....	1.35	1.31	1.10	1.12	.87	1.09	1.19	.76	1.36	1.33	1.14	1.20	1.16	.61
Average (including computed figures).....	.97	1.36	1.46	1.41	1.36	1.37	1.30	1.15	1.08	.97	.84	.95	.84	.64
Average (excluding computed figures).....	.71	1.30	1.46	1.41	1.36	1.37	1.32	1.20	1.10	.94	.78	.83	.62	.42

Note: Figures in heavy type are computed.

The data used in constructing the growth curve given in Fig. 2 comprise measurements made in all months of the year, thereby eliminating the seasonal variation in the rate of growth. As nearly as we could make it, the only variable was age.

The time of most rapid growth for sugar cane is found to be when the cane is from 5 to 10 months old inclusive, being most rapid when 6 months old. After 10 months the rate of growth slows down, and our data tend to show that at 17 months the rate of growth is less than half what it was at 6. Of course this refers to weight only and has no reference to sugar formation. We now have work under way from which we hope to determine the rate of sugar formation in the same way as shown here for weight. The maximum rate of sugar formation will, of course, be later than the maximum for growth.

When a cane joint is first beginning to form it contains starch only, which is used in the formation of fiber. Soon the leaf attached to the joint begins to function and sugars are formed, which are transferred to the joint. A part of these sugars is consumed during growth, the rest is conveyed to the more mature joints. At the moment a joint is full-grown it contains little sucrose and much reducing sugar. From this time on more and more of the sucrose elaborated by the leaf is stored in the joint until the leaf dies off. After this still more sucrose may be stored in the joint, having been transferred from the less mature top.

From this we see that the period of most rapid growth is not necessarily the period of most rapid storage of sucrose, as a great deal of the sugars formed are used to supply energy to the plant.

#### THE BEST TIME AT WHICH TO PLANT FOR THE MOST RAPID CLOSING-IN

In Table 3 we give the total growth made by sugar cane during the first five months after planting for plantings during all months of the year. We adopted

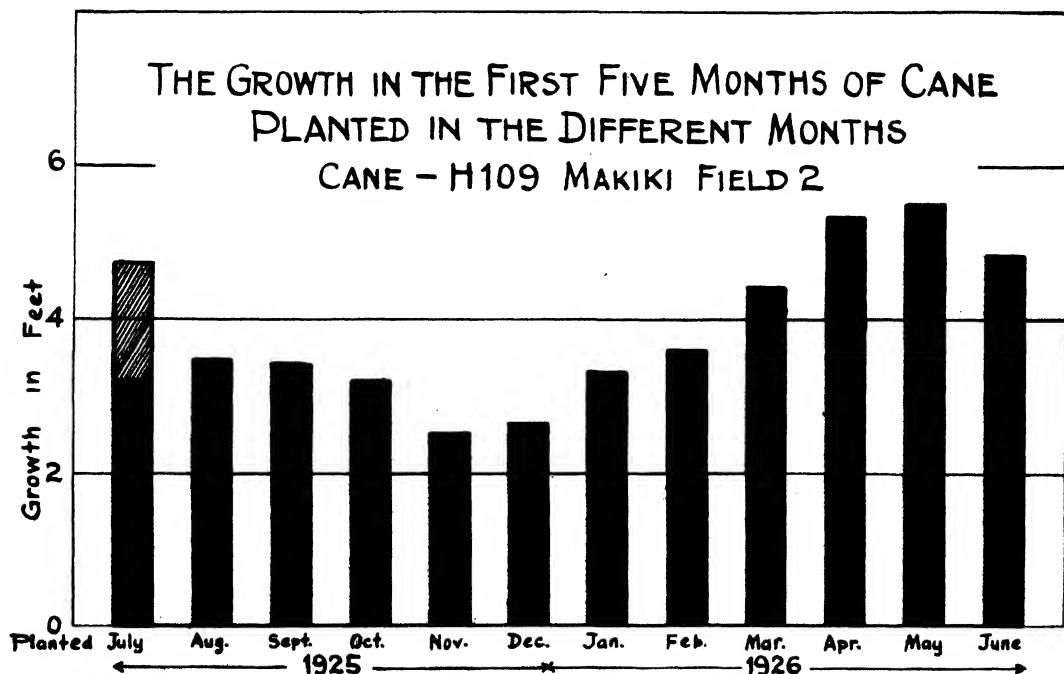


Fig. 3

five months as the period when "millable cane" is beginning to form and the crop fully closed in. The same are given graphically in Fig. 3.

TABLE 3  
THE GROWTH IN THE FIRST FIVE MONTHS OF CANE PLANTED IN THE  
DIFFERENT MONTHS

H 109 CANE, MAKIKI, FIELD 2

Cane planted first day of	Length of cane in feet	Total Growth degrees (July:Jan. 10-4)	Growth in feet per degree
1925, July . . . . .	3.18 (4.72)	175	.018 (.027)
August . . . . .	3.51	150	.023
September . . . . .	3.45	130	.027
October . . . . .	3.19	110	.029
November . . . . .	2.57	105	.024
December . . . . .	2.68	110	.024
1926, January . . . . .	3.33	125	.027
February . . . . .	3.63	145	.025
March . . . . .	4.44	175	.025
April . . . . .	5.37	190	.028
May . . . . .	5.50	195	.028
June . . . . .	4.85	190	.026

In studying Table 3 you will note that the growth in feet per growth degree for cane planted in July, 1925, is only .018 foot, while plantings for all other months show fair uniformity, with the lowest growth at .023 foot per degree. The average for the eleven months, omitting July, is .027 foot. We believe this figure of .018 foot for July to be wrong, and that it would be more accurate to use the average for the other months, namely, .027 foot per degree. On this basis the total growth for the first 5 months for cane planted in July would be 4.72 feet instead of 3.18. This added growth is shown in Fig. 3 by the cross-hatched part of the July column.

These data show that the best months in which to plant in order to obtain the most rapid closing in are March, April, May, June and July. This fully confirms our practical observations.

The poorest months in which to plant are seen to be November and December.

## Inoculation Experiments With Sugar Cane Stem Galls

By H. ATHERTON LEE

The following is a copy of my notes of a series of inoculation experiments to determine the transmissibility of stem gall tissue to healthy cane:

*May 20, 1927:* Stalks showing young, fresh, actively growing stem galls were taken from stools of U. D. 1, at the Mid-Pacific Institute plots. These galls were from the topmost joints of the cane, still uncolored and protected from weathering by the surrounding leaf sheaths. They were taken to the Manoa substation, taking care to see that they were wrapped well, to avoid spread of infection, if infectious, by handling, etc.

At the Manoa substation, healthy tissue from the top joints of U. D. 1, entirely unaffected with stem galls was macerated with sterile water with a mortar and pestle and was used as an inoculum for controls.

The cane to be inoculated was U. D. 1, never having shown a case of node galls, about 1 year old. Thirty days previously it had received an application of ammonium sulphate to put the cane in a vigorous, actively growing condition.

Twenty stalks of such cane were selected, and the leaf sheaths towards the top split and crowded to the side with a scalpel, allowing inoculation of very young joints near the top of the cane, such joints being newly formed and actively growing. The inoculum of healthy tissue was placed with a sterile needle in the rind tissue of such young joints.

An inoculum was then prepared of the fresh young stem galls collected at the Mid-Pacific Institute, crushing the galls with a small quantity of sterile water in a mortar and pestle. With this inoculum and the same technique as for the controls, young, newly formed nodes of 20 additional stalks of U. D. 1 were inoculated. A sterile needle was used to puncture the cane rind and introduce the crushed tissue of the inoculum. The leaves and leaf sheaths of the cane stalk were then allowed to push back over the inoculated node, maintaining natural moisture. This moisture was supplemented by wet cotton and the whole top of the inoculated stalk was then wrapped in paraffin paper and then opaque newspaper to maintain moisture and exclude sunlight.

The results of such inoculations follow:

Stalk No.	Inoculum	Result	Date
1	Crushed healthy cane tissue.....	Negative.....	June 21
2	" " " " "	" .....	July 26
3	" " " " "	Negative(a.....	July 26
4	" " " " "	Negative(a.....	June 21
5	" " " " "	Negative.....	, July 26
6	" " " " "	Negative(a.....	June 21
7	" " " " "	Negative.....	
8	" " " " "	" .....	July 26
9	" " " " "	" .....	July 26
10	" " " " "	" .....	July 26
11	" " " " "	" .....	July 26
12	" " " " "	" .....	July 26
13	" " " " "	Negative(a.....	July 26
14	" " " " "	Negative.....	June 21
15	" " " " "	" .....	July 26
16	" " " " "	" .....	July 26
17	" " " " "	" .....	July 26
18	" " " " "	" .....	July 26
19	" " " " "	" .....	July 26
20	" " " " "	" .....	July 26
21	Crushed stem gall tissue.....	Negative.....	June 10
22	" " " " "	" .....	July 26
23	" " " " "	" .....	July 26
24	" " " " "	Negative(a.....	June 10
25	" " " " "	" .....	June 10
26	" " " " "	" .....	July 26
27	" " " " "	" .....	June 21
28	" " " " "	Negative.....	July 26
29	" " " " "	" .....	July 26
30	" " " " "	" .....	July 26
31	" " " " "	Negative(b.....	July 26
32	" " " " "	Negative.....	July 26
33	" " " " "	" .....	July 26
34	" " " " "	" .....	July 26
35	" " " " "	Negative(b.....	July 26
36	" " " " "	Negative.....	July 26
37	" " " " "	" .....	June 21
38	" " " " "	Negative(a.....	June 21
39	" " " " "	Negative.....	July 26
40	" " " " "	" .....	July 26

(a)—A slight scarcely noticeable formation of callus occurred on the rind tissue surrounding the inoculation puncture; it could not be considered a stem gall.

(b)—A slight nub or swelling occurred in the rind in the position of the meristematic tissue just above the root band; such swellings could not be considered stem galls; they also occurred on uninoculated stalks.

*Conclusion:* The results of this experiment are as definitely negative as could be expected in any experimental work. They lead to the feeling that if stem galls are infectious, transmission must be made by insect vectors. Another possibility that begins to appear promising for investigation is the relationship of insects as direct producers of such proliferating tissue.

July 29, 1927.

## Hot Water Heated Propagating Benches

BY R. E. DOTY

The work of the seedling season of 1925-1926 demonstrated that bottom heat was effective in securing a good germination of cane fuzz during the winter months.

During the past season, 1926-1927, a series of hot water heated benches were developed. Two types were built and operated very successfully during the entire season. The first type, which was constructed in the open, was equipped with a cloth cover for rain protection; the other type was built without a cover to be used only in a glasshouse.

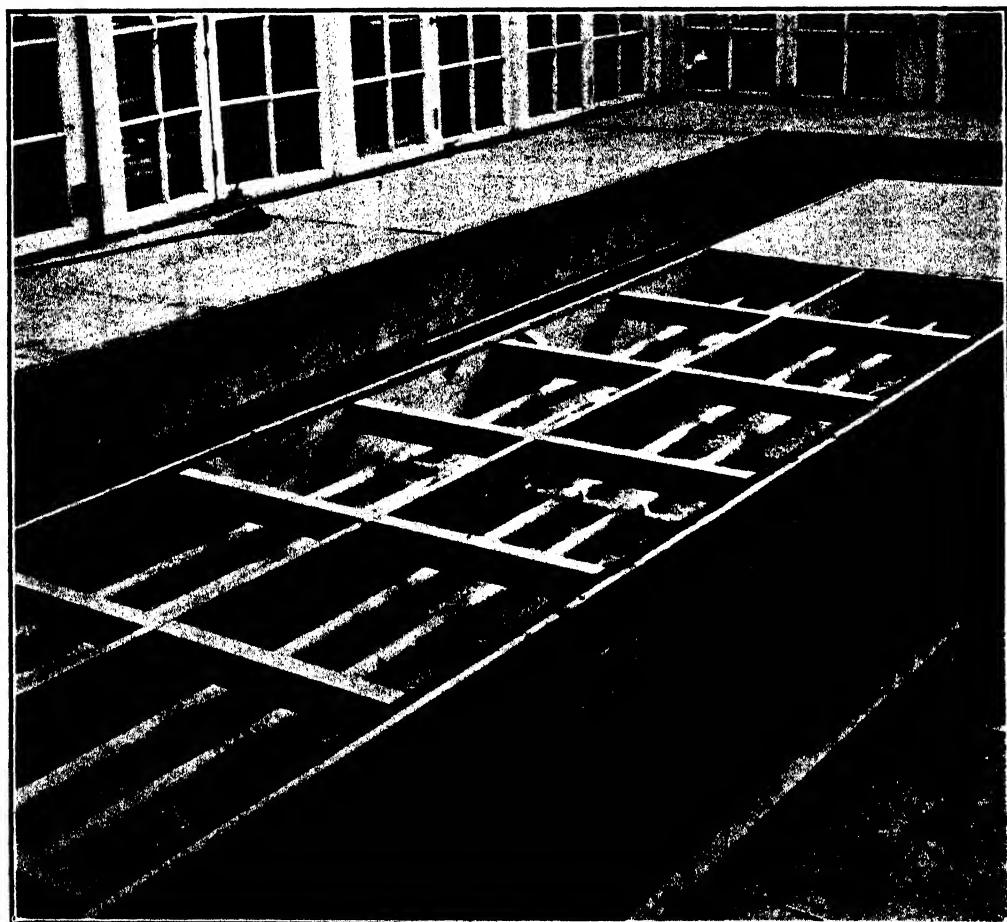


Fig. 1. Hot water heated glasshouse propagating bench. This illustration shows the general method of single wall construction for inside benches. (Outside benches differ in that they have a double side wall, heated pipes placed with a slight fall [1" to 20'], and a cover for rain protection.) The bottom of the bench is covered with rice hulls. The heated pipes are resting on 2x3 cross pieces. The iron cover or plate is shown at the extreme right.

## CONSTRUCTION

Each of the outside benches consists of a large boxed air chamber containing coils of hot water pipes, covered by sheets of galvanized iron, through which the heat from the air around the pipes is transmitted to the bottoms of the seed flats. This hot air chamber is approximately 4 feet wide, 32 feet long, and 10 inches deep. The framework is made of 2"x3" material. The bottom is constructed of 1"x6" tongue and groove. The sides are double walled; a 1"x12" on the outside and a 1 $\frac{1}{4}$ "x10" on the inside with a 1 $\frac{1}{2}$ " space between. The upright supports (2"x3") come up into this space and hold the outside and the inside boards in place. The floor is notched around these 2"x3" to make a tight fit. This space is filled with dry rice hulls. A two-inch layer of rice hulls also forms excellent insulation for the bottom of the hot air chamber. Old bagasse board and asphalt sheathing are also good as insulating materials. (See Fig. 1.)

The heating unit consists of four lines of 1 $\frac{1}{4}$ " galvanized pipe placed inside of the bench and running its entire length. This pipe is connected in one continuous line, coiled so that the pipes are equidistant from each other and from the side wall. The intake pipe enters the end of the box about 1 $\frac{1}{4}$ " down from the sheet iron cover and the coil is adjusted and blocked to give a slight fall, about 1 $\frac{1}{2}$ " to each length of 32 feet of pipe. This allows the return pipe to leave through the end of the hot air chamber very near the bottom. This method of laying the pipe in the hot air chamber is an aid to the hot water circulating system. The return pipe also runs next to and parallel with the intake. This equalizes the heat throughout the air chamber, as the cooler return pipe is next to the hot intake.

In one bench, six lines of 1" pipe were used. In this case extra strips of tin and iron were wired to the pipes to form radiating fins to help release the heat more rapidly from the pipes to the air. (See Fig. 2.)

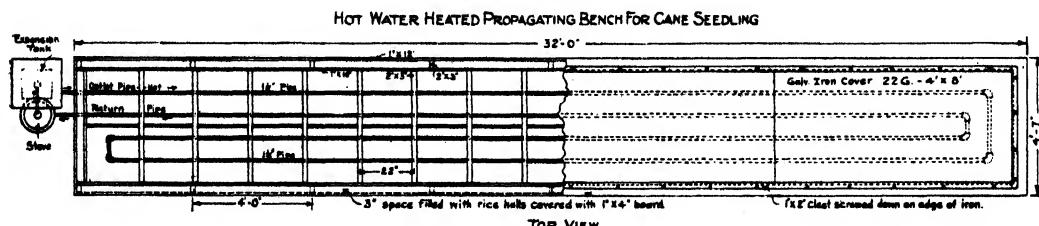


Fig. 2

After the heating pipes are in place, the benches are covered with sheets of 22 G. galvanized iron on which the seed boxes are to be placed. This iron cover is supported and held level by cross joists (2"x3") which are placed directly over the pipes, and spaced every 22 to 24 inches. The edges of the iron sheets are lapped directly on one of these joists. To make a rather tight fit between the iron and the wood edge of the air chamber, strips of asphalt felt paper are placed between the iron and the edge of the 1 $\frac{1}{4}$ "x10" side board. This edge is held down snugly by a 3 $\frac{1}{4}$ "x1" strip screwed down with No. 9 1 $\frac{1}{2}$ " wood screws. The

screws are placed slightly away from the edge of the iron to allow sufficient space for expansion of the iron when heated.

### COVERING

The simplest arrangement for covering the benches is to construct a gable-roofed frame of 1"x4" material and cover with cloth.

Strips of unbleached muslin (waterproofed with paraffin dissolved in gasoline) are fastened to this frame at the top. The bottom of this strip of cloth is fastened to a wood strip (1"x3") to form a rolled drop-curtain. This curtain can be rolled up to the top of the frame in good weather or dropped down, to form a complete cover over the boxes, in rainy weather. During the night this cover also serves to hold the heat which is constantly radiating from the surface of the soil in the flats.

### HEATING APPARATUS

Having constructed a satisfactory bench, it is then necessary to decide what source of heat should be used. The experimental work was done entirely with a Perfection 2-burner blue chimney kerosene hot water heater. (See Fig. 3.) This stove is commonly used to heat a water tank in dwellings. It has capacity sufficient to heat one large table 4'x32'. After constructing four large outside benches, and with the possibility of building still more in the future, there was some thought of installing a low pressure hot water boiler to burn fuel oil. One boiler of this type would care for a goodly number of seedling propagating benches. But it was finally considered better to use kerosene heaters so that much smaller units could be operated independently.

In order to give positive circulation with a gravity circulating hot water system, it is necessary to have the expansion tank directly above the stove. This tank is open at the top and allows the escape of air or steam from the hot water without getting into the heated coils. In the first bench this tank is a 5-gallon oil can packed in a box with a 2" layer of filter-cel insulation around the sides and bottom. The hot water rises through the coils of the stove and arrives in the tank at the highest temperature as well as at the greatest height in the water circuit. From a point on the side of the tank the water is conducted through a pipe into the table and on through the coils. These coils have about one inch of fall for every 20 feet of pipe. The water continually cools as it travels through the coils, finally arriving at the bottom of the stove again to be heated and again circulated. This water will make one complete circuit in about twenty minutes, starting with a tank of hot water, a good flame, and cold return water.

Heat may be applied to three benches in series by the following method:

Two large sized (No. 421) Perfection kerosene hot water heaters are installed together in a specially built 5'x6' house. (See Fig. 4.) Both stoves are connected to the same expansion tank, which is placed in the roof directly over the stoves. This tank is kept full of water by means of a city water connection, controlled by a ball and cock float valve of a design commonly used in toilet tanks. The hot water

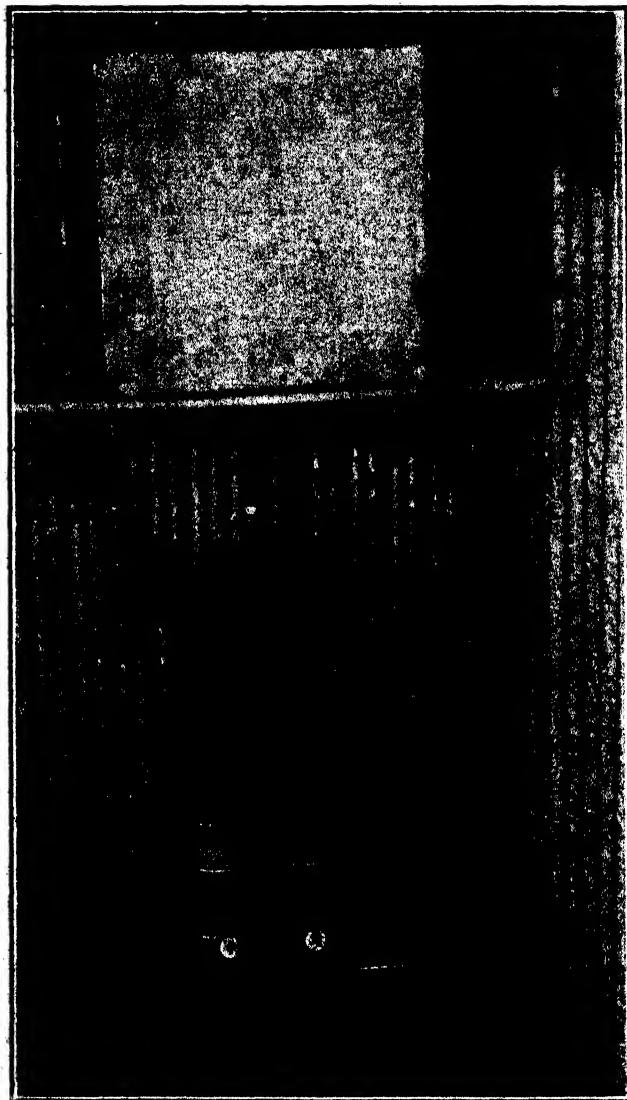


Fig. 3. A Perfection two-burner stove used to heat one 4'x32' outside propagating bench for cane seedling work. Note that the oil tank is outside the wall to reduce fire hazard, as this type of stove does not have a thermostatic cut-off. Oil feed pipe shown at lower right. Expansion tank is shown directly above the stove. Stove house constructed of corrugated iron.

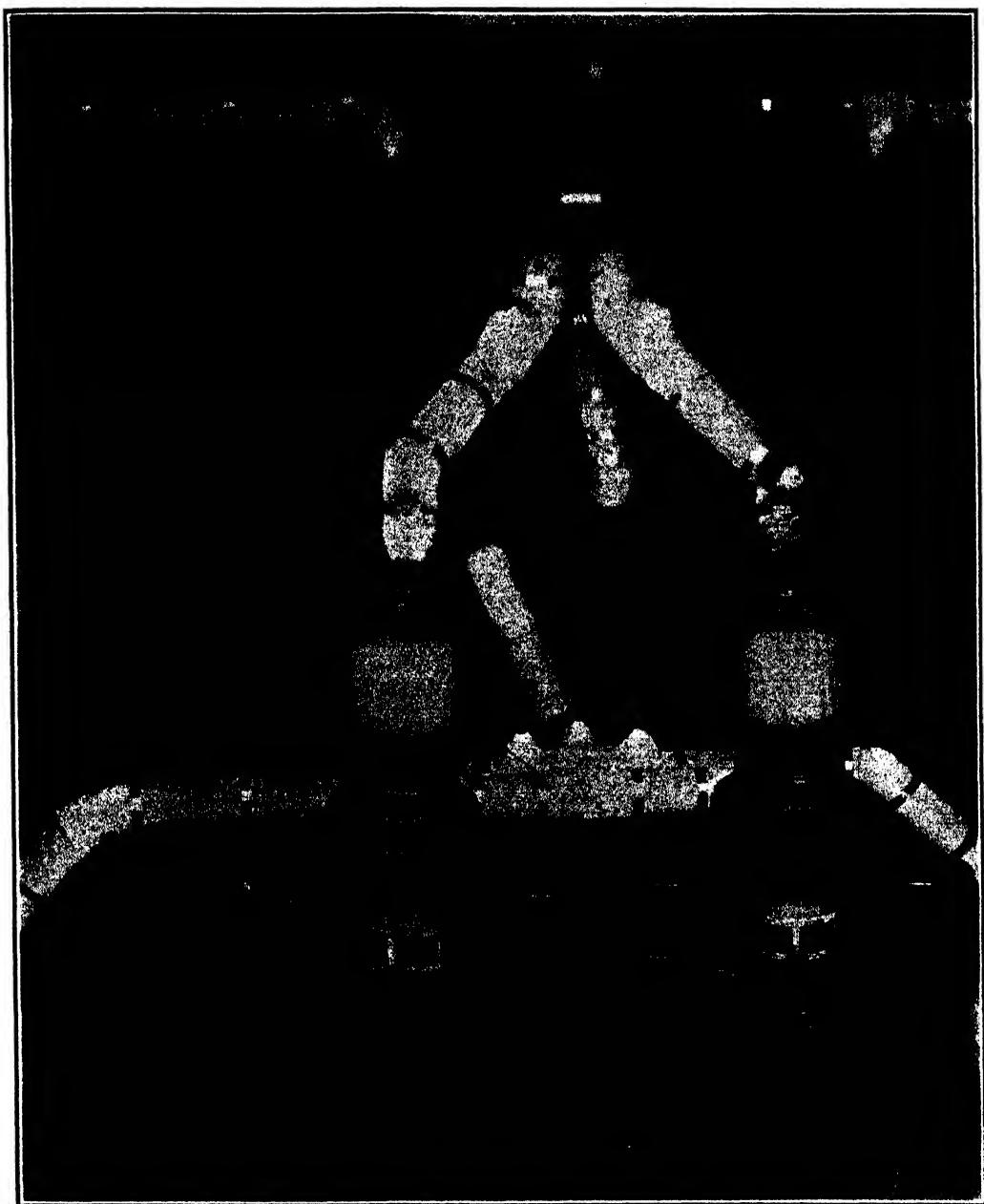


Fig. 4. A two-stove gravity circulating hot water heating unit. These stoves operate three outside propagating benches, each bench 4'x32"x10". The cooler return water coming from the three benches enters the stoves at the lower end of the stove coils and the heated water rises to the expansion tank directly over the stoves. Here it is led by three outlet pipes to the bench coils (two outlet pipes shown). Note valves on outlet and return pipes to give flexibility in operation. One or both stoves, one or more benches may be operated alone.

pipes from the three benches are connected to this tank and the returns brought back to the bottom of the stoves. By means of valves on the outgoing hot water lines and the return lines, it is possible to operate one, two or three benches, and one or both stoves at will. This gives great flexibility in operation. All piping in this installation is of  $1\frac{1}{4}$ " galvanized. Unions are put in all connecting lines between the stoves, tank and benches, to enable repairs or changes to be made easily. All exposed pipes are lagged with magnesia pipe covering and then covered with roofing paper. The return pipes from the three benches are brought to a central point back of the stoves and joined by means of proper bushings to a  $2\frac{1}{2}$ " double cross tee. Then two lines, one to each stove, are taken from the cross tee. This equalizes the flow and temperature of the water to each stove. A thermometer is placed through a rubber cork in a tee on the return line from each bench to check the temperatures of the return water. With the valves open and the same number of seed flats on each table, the temperature difference between the three thermometers is less than  $2^{\circ}$  F., with the water at  $170^{\circ}$  F.

#### GLASSHOUSE BENCHES

Two large U-shaped benches were built in the glasshouse this season. They were made slightly narrower (42") than the outside benches to make the best use of space. One bench was built close to the wall on three sides of the glasshouse. This bench was about 90' long.

A gas hot water heater and a "Duro" pump of 80 gallons per hour capacity, which were on hand at the Station, were used in the first installation. It was not practical to try to make this system circulate by gravity, due to the great length of this bench, so the pump was a necessity.

The general construction of these benches followed the plan of the outside benches, except double side walls were unnecessary. Any heat that radiated through the side would be useful in raising the temperature of the air in the glasshouse.

The iron used for the top was 24 gauge, 42" wide instead of 22 G. 48" wide, being both narrower and lighter in weight.

As this system was operated by a pump, six lengths of 1" pipe were used for the heating coils instead of  $1\frac{1}{4}$ ".

When the second bench was built in the glasshouse, it was necessary to use a larger pump and have an auxiliary kerosene heater installed in the circuit to heat both benches properly. By connecting the return pipes from each bench to both pumps, the water of both benches can be maintained at the same temperature. (See Fig. 5.)

#### OPERATION OF HEATED BENCHES

##### OIL BURNED

The stoves to heat the benches burned kerosene oil. The small 2-burner stove operating one large outside bench burned one gallon of oil in 9 to 10 hours, depending on the height of flame.



Fig. 5. General view of seedling work, 1926-1927. Hot water (kerosene units) used for heating benches in foreground and in glasshouse.

The large super flex burner stoves (No. 421 Perfection) burned one gallon in 8 to 10 hours, depending on the height of flame. Two of these stoves operated three large outdoor benches.

#### TEMPERATURES OBTAINED

These benches were operated for approximately four months (December to March). During cold and cloudy weather the stoves were kept going at varying flames during the day, according to the amount of sunshine. The burners were turned up full at four o'clock in the afternoon and turned low again at eight o'clock the next morning. This kept the water warm at all times. During warmer weather the stoves were turned out at 8 a. m. and turned on again between 3 and 4 p. m.

Temperature records were kept for each table recording the temperature of the hot return water, and the reading of one or two thermometers on top of the soil in the flats. These readings were taken every two hours, beginning at 6 p. m. and continuing until 8 a. m. each day. These records were kept for several weeks and gave information as to the fluctuations occurring during the night.

The hot water from the stoves generally entered the expansion tank at about 205° to 210° F. The return water would be cooled down to between 170° to 180°, depending on the outside atmospheric temperature. On an average night,

when the return water was 175° F., the temperature of the fuzz under the waxed paper would be about 87° or 88° F. On very cool nights (50°-65°) the fuzz temperature would be lower for the given water temperature and the reverse would be true on warmer days.

In order to visualize the differences in the temperatures of the heated seed boxes and the outside air at night, the following brief table is inserted here. This table gives the average monthly mean minimum temperature for the months during which the heated benches were operated:

Month	Mean monthly minimum	Lowest temperature recorded at night
December, 1926 .....	64.71° F.	58° F.
January, 1927 .....	64.32° F.	58° F.
February, 1927 .....	60.86° F.	50° F.
March, 1927 .....	64.94° F.	59° F.

During these months the temperatures at night under the paper were maintained from 86° to 92° F. There was a remarkable uniformity in the temperatures throughout the night for a given flame height of a stove. A bench that was running at 88° F. would not vary over 1° during the night. If there was a drop in temperature, it generally occurred at the 4 a. m. or 6 a. m. reading. The temperature rarely reached 94° F. It was practically impossible to overheat the benches unless there was full sun as well as artificial heat.

After the young seedlings have germinated, it is the standard practice to remove the wax paper. This removal of the wax paper causes a drop of 8° to 10° F. in the flats on the outside benches. Windy weather causes the temperatures to drop in all outside benches, though it makes little difference in the glasshouse.

Under this system of bottom heat and the wax paper covering over the fuzz, germinations occur regularly on the morning of the third day after planting. The shortest time that we have on actual record is forty hours. This was obtained by planting at 4 p. m. on a given day and examining the flats at 8 a. m. on the second morning following. Germinations were numerous, and large enough to be easily seen.

#### SEED FLATS WITH SHEET IRON BOTTOMS

A study was made of the types of seed flats best adapted to transmit the heat from the hot iron cover of the heated benches to the soil in the seed flat.

A sample lot of seed flats were made, having the following differences:

1. Normal  $\frac{3}{8}$ " wood bottoms,
2. 1" sand screen or chicken wire with burlap bottoms, and
3. Galvanized sheet iron (28 G.) bottoms with drainage holes.

These three types of boxes were placed on a heated bench and temperatures were taken at intervals over a period of two days. These tests showed that the flats having sheet iron bottoms heated up more rapidly and, for a considerable period, maintained temperatures about 2° F. higher than the boxes having wood bottoms. If the heat was applied for five or six hours or more, the temperature of

the soil in the boxes having wood bottoms would eventually be the same as the soil in the boxes having iron bottoms.

The boxes having various forms of wire mesh bottoms and burlap, heated up almost as good as the iron bottomed boxes. But the great defect of this type of box was the sagging of the bottom while being carried from one place to another. The weight of the soil invariably sagged the bottom so that, when the box was placed on a level bench, large cracks appeared in the surface of the soil. These cracks undoubtedly cause the death of many seedlings. The box with the sheet iron bottom with drainage holes was adopted as being the best for applying artificial heat.

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## Some Notes on the 1926-27 Seedling Work

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By J. A. VERRET, A. J. MANGELSDORF AND C. G. LENNOX

### ON PRESERVING CANE STALKS

#### LAYERING

In a recent paper by Venkatraman and Thomas\*, a method is described whereby cut tassels are kept alive in the following manner: The roots on a portion of the stalk just above the ground are induced to develop by surrounding this portion with soil which is kept moist. The work is done at the first indication of tasseling, so that there will be ample root development by the time it becomes necessary to isolate the tassel. Just before blooming begins the stalk is cut at a point below the "layer" and the stalk is thereafter kept alive by the roots within the layer.

This method was given rather an extensive trial the past season. Instead of soil a "layer" of sphagnum moss was used. It was held in position by wrapping it with a bandage of cotton cloth dipped in paraffin to prevent the absorption of water and subsequent loss through evaporation. The "layer" was kept moist with water and with dilute nutrient solution. It was found that rooting took place more readily at the upper part of the stalk where the cane was not so hard. Considerable difference was observed in the length of time required by different varieties to send out roots.

Whenever a sufficient amount of root development had occurred previous to cutting, the stalks treated in this way remained as fresh as though still attached to their original roots. Where the number of roots in the layer was limited, a certain amount of wilting and premature dying occurred.

The method has this disadvantage: the layer must be applied some weeks before tasseling and it must be kept constantly moist thereafter. This requires consid-

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\* Isolation of live arrows from undesired pollen through artificial rooting of canes. T. S. Venkatraman and R. Thomas, *Ag. Jour. of India*, Vol. XXI, Part III, May, 1926.

erable labor. Meanwhile the layered tassels may be rendered unfit for use by the high winds which may be expected at that season. Furthermore, it is difficult to anticipate in advance just how many tassels of each of the varieties will be required.

At the present time the method appears to present a number of disadvantages and few advantages as compared to the sulphurous acid method.

#### SUPPLYING WATER UNDER PRESSURE

Proceeding on the assumption that the wilting of cut tassels is due to their failure to take up water rapidly enough to maintain turgidity, an attempt was made to increase the water intake by supplying water under pressure. This was accomplished by connecting the cut ends of the stalks by means of rubber tubing to a pipe line in which a pressure of four pounds per square inch was maintained. Without considering resistance, this amount of pressure is sufficient to raise a column of water to a height well above the tops of the tassels. The cut midribs of the leaves did, in fact, exude water, indicating that the pressure was effective. Five tassels were thus treated, while five tassels placed in jars of water and five in jars of .03 per cent sulphurous acid served as checks. The tassels supplied with water under pressure bloomed more normally and lived longer than those in water without pressure, but neither succeeded as well as those in the sulphurous acid solution.

#### SULPHURIC ACID

Two strengths of sulphurous acids, .015 and .03 per cent of SO<sub>2</sub>, respectively, were tried rather extensively in comparison with each other during the past season. The stronger solution gave the better results. Indeed, nothing has thus far been found which is superior to a .03 per cent sulphur dioxide solution for keeping cut cane stalks alive and fresh.

#### INDOOR CROSSING

A method of crossing which was given an extensive trial the past season with but little success is the following: The female tassels were kept in canvas houses in which a high humidity was maintained by constant spraying. It was thought that the reduced transpiration in these so-called "humid houses" should help to prolong the life of the cut tassels.

The male tassels were kept in other houses under ordinary atmospheric conditions and were so placed that their pollen, when shed, would fall upon sheets of glazed black paper. The pollen was then carried to the humid houses and dusted upon the female tassels.

The percentage of germination obtained in this way was very low. It is probable that there was a certain amount of loss of viability of both pollen and stigmas due to our inability to get the pollen to the stigmas promptly enough. It is also possible that the reduction of transpiration in the humid houses is actually detrimental, since it cuts down the volume of the stream of sap passing upward in the stalk and therefore also the flow of nutrients from the stalk to the tassel.

### EMASCULATION OF CANE TASSELS

A problem sometimes encountered in the crossing work is that of obtaining crosses between two varieties, each of which is self-fertile. One method of attack is to place the two varieties together and to rely on the hope that in addition to the seedlings resulting from selfing a percentage of crosses will also be found.

Another possibility is to remove the anthers from one of the varieties before it has shed its pollen, using it as the female parent. Castration by hand, however, is so laborious as to be impracticable. A few preliminary experiments were carried on this season on removing the anthers by means of suction. The suction hose of a vacuum cleaner was equipped with a glass tube drawn to a diameter just large enough to permit the ready intake of the anthers. It was found that the tassel could be gone over quite rapidly by this means. The efficacy with which the anthers are removed depends on how well they are extruded and this depends more or less upon the variety. In some varieties the anthers remain partially enclosed by the glumes and their removal by suction when in this position is difficult.

The method has no place except in special cases where the self-fertility of each of the two parent varieties is so great as to seriously reduce the percentage of crossing.

### HEATING OF GERMINATION TABLES

A method of heating which has been tried out the past season is the following: the germination table, which is 8 feet long and 4 feet wide, is constructed entirely of metal. The legs and cross pieces are  $1\frac{1}{4}$  inch iron pipe, while a piece of sheet iron (22 gauge) serves as the top. A layer of soil of the usual depth is placed directly upon the sheet iron so that we actually have what amounts to a large seedling flat 8 feet long, 4 feet wide and 2 inches deep, with a metal bottom. The source of heat is an inexpensive kerosene stove placed directly beneath the center of the table. The heat is diffused as much as possible by means of a baffle plate of sheet iron, 2 feet square, suspended horizontally immediately above the heater. The heat is confined beneath the table by means of cotton sheeting which goes entirely around the sides except for a door 2 feet wide immediately in front of the stove. This door, which affords easy access to the stove, is closed by means of a drop curtain.

The construction of such a table is fairly cheap and very durable, and the method of supplying heat is simple. The heat distribution, while not as uniform as might be desired, is fairly good. While not as desirable as a hot water installation, it gives decidedly better results than an unheated table.

### POLLEN PRODUCING CAPACITY OF VARIOUS CANES

In planning the season's crossing program it is helpful to have at hand information concerning the pollen producing capacity of the varieties to be used. The amount of pollen produced by a given variety determines to a large extent whether that variety can be most advantageously used as a male or as a female

parent. The characteristic is known to vary with environmental conditions, but on the whole it is remarkably constant.

Observations on this point on some of the more important varieties handled during the past season are listed below:

Variety	Pollen	Variety	Pollen
Badila	Abundant	Makaweli 3	Abundant
25 C 4	Abundant	Mexican Bamboo	Scanty
25 C 7	Scanty	P. O. J. 36	None
25 C 8	None	P. O. J. 213	None
25 C 21	None	P. O. J. 234	None
25 C 30	Fair	P. O. J. 979	None
25 C 31	None	26 Q H 1	Abundant
25 C 40	Scanty	26 Q 534	Abundant
25 C 46	None	26 Q 562	Abundant
D 117	Abundant	26 Q 1079	Fair
D 1135	Fair	Red Tip	Scanty
H 27	Abundant	Rose Bamboo	Scanty
H 109	Fair	Striped Mexican	Scanty
H 146	Scanty	Striped Tip	Scanty
H 227	Abundant	20 S 16	Abundant
H 456	Abundant	Tiboo Mird	Scanty
H 8965	Abundant	Uba	None
H 9802	Scanty	U. D. 1	None
H 9811	Fair	White Bamboo	Fair
Keni Keni	None	Wailuku 9	Fair
Lahaina	None	Waipahu 122	Scanty
Lahi	Abundant	Yellow Caledonia	None
Makaweli 1	Fair	Yellow Tip	Scanty

#### FERTILITY OF UBA SEEDLINGS

So far as they have been observed the first generation Uba hybrids have proved to be quite male-sterile, that is, they produce no good pollen. Only one exception has been found thus far,—U. D. 50 appears to be slightly male-fertile.

Observations were made the past season on the Uba quarter-breeds (26 Q series) resulting from crossing the first generation hybrids (half-breeds) back to the big-sticked canes. The pollen fertility in this generation is somewhat increased but there is still a high degree of sterility. About one seedling in five produces some pollen and only about one in fifty produces it in abundance.

The Uba quarter-breeds must therefore be used for the most part in crossing as female parents. Those producing enough pollen to serve as male parents are the exception.

#### TREATMENT OF FUZZ TO REDUCE ITS BULK

Some of our most desirable parent varieties give extremely poor germinations, necessitating the planting of a large amount of fuzz in order to obtain even a few seedlings. A method whereby the volume of the fuzz could be reduced would result in considerable saving of space, labor and expense. A means of separating

the kernels from the surrounding glumes and from the sterile seeds, would be desirable, possibly something in the nature of a miniature threshing machine. However, the difficulties in the way of threshing a material like cane fuzz are obviously very great.

A few preliminary experiments indicate that dipping the fuzz for one minute in concentrated sulphuric acid and washing immediately on a fine meshed wire sieve under a stream of water cuts down the bulk of the fuzz quite materially. The percentage of viable seeds is apparently slightly reduced by the treatment, but the rate of germination is more rapid, the treated fuzz germinating one to two days ahead of the untreated checks. The fuzz must, of course, be planted immediately after treating.

#### TREATMENT OF FUZZ AFTER PLANTING

After the fuzz has been planted and previous to its germination, some means of covering the flat is desirable to prevent so far as possible the evaporation of moisture and the cooling which accompanies it. Waxed paper serves the purpose very well in the greenhouse, but it is too easily blown about on the outside tables. Glass panes partially shaded with whitewash are satisfactory, but they are expensive and breakable. A suitable material, except for its rather high price, is Celoglass, a glass substitute made by coating wire screen with a celluloid-like substance. It may also be used for the construction of hotbed sash. It has an additional advantage in admitting a considerably larger percentage of ultra-violet rays than does ordinary glass.

#### SEEDLINGS FOR EYE SPOT AREAS

With the cooperation of the pathology department, seedlings intended for eye spot areas are subjected to a preliminary elimination while still in the flats by spraying them with an infusion of eye spot spores. Practically all of the seedlings develop the disease, and many of them succumb very quickly to its effects. A few, however, show a high degree of tolerance. It is reasonable to suppose that the survivors will on the whole be more resistant than the average of the lot before treatment.

## Effect of Wind on Cane Growth

By J. A. VERRET AND R. H. McLENNAN

In this test we endeavored to determine the effect of moderate wind on cane growth. The wind effect was produced by means of 16-inch electric fans, each plant having a fan blowing directly upon it. We did not have the instruments, so the wind velocity was not determined. The wind was not of such force as to cause appreciable physical damage to the cane leaves. The plants were grown in

16-inch concrete pots and in large galvanized iron tubs. Every effort was made to have plants of the same size at the start. All the seed pieces used were of the same size and weight.

We conducted two series of experiments. In one series the same amount of water was used in all pots, fan and "no fan." We tried to regulate the amount of water so as to give optimum moisture to the "no fan" pots.

In the other series we weighed the pots each day and replaced the evaporated water. In this way all pots were kept at a moisture content of 25 per cent on the dry basis.

#### CONSTANT MOISTURE SERIES

In the constant moisture series we used twelve 16-inch pots. Six of these were exposed to the wind effect from six 16-inch fans. The remaining six pots were used as controls. All pots were kept in the greenhouse in order to control the moisture. The surfaces of the pots were kept covered in order to have a more uniform moisture content in all pots. During the course of the experiment one of the "no fan" plants became diseased and made very poor growth compared with the others. It was therefore discarded.

#### THE EFFECT OF WIND ON CANE GROWTH IRRIGATION UNIFORM TO ALL POTS

First Trial

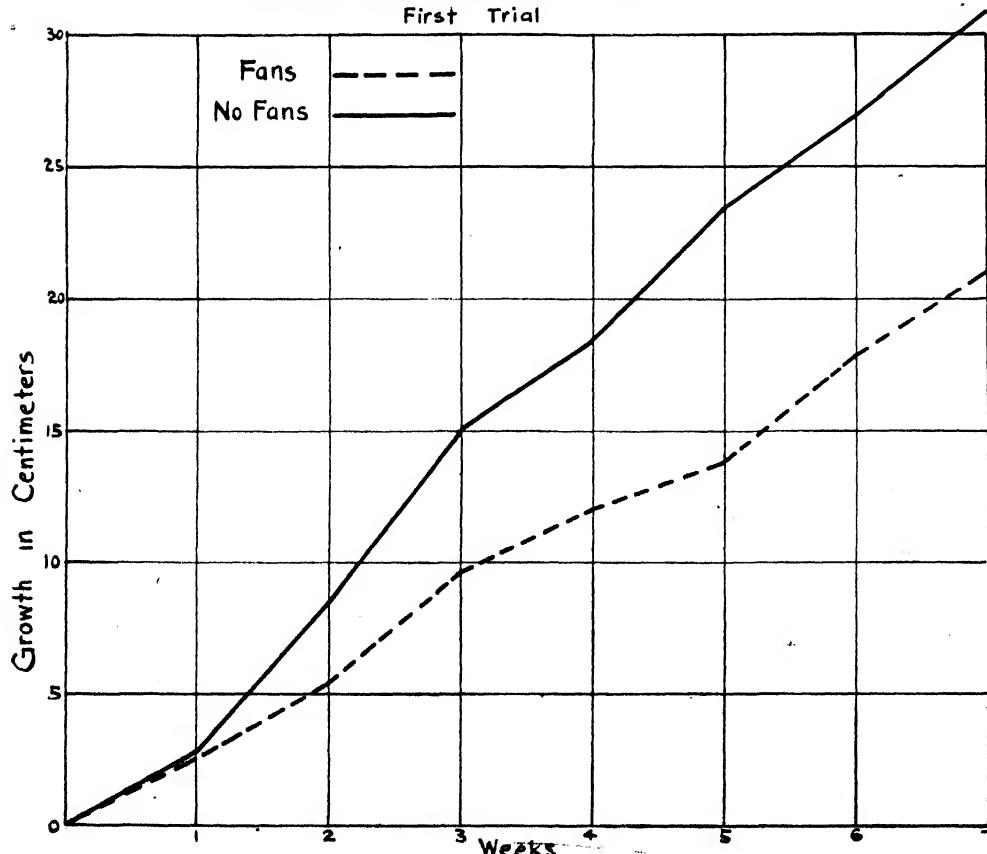


Fig. 1

The results obtained are summarized in the following table:

	Total No. of shoots	Avg. height of primary shoot	Green weight of plants	Per cent loss in weight
Fans .....	16	7.9	22.3 ounces	14
No Fans .....	11	7.2	26.6 ounces	

These results, for the condition of the experiment, would indicate that the fans tended to increase stooling in the ratio of 16 to 11. The average length of the primary shoots was also somewhat more for the fan pots, but the total green matter produced was 14 per cent less in the fan pots. The shoots in the fan pots were smaller in diameter than were those in the "no fan" pots. We do not know whether the increased stooling noted in the fan pots is significant or not. The small number of plants involved introduce a large probable error. Also, on account of the small size of the pots, the plants were becoming pot bound so the test was stopped at the end of 56 days. Had the test continued longer the plants in the "no fan" pots might have stooled out later. The extra stooling in the fan pots may have been caused by the constant shaking of the plants. This loosened the

#### THE EFFECT OF WIND ON CANE GROWTH IRRIGATION UNIFORM TO ALL POTS

Second Trial

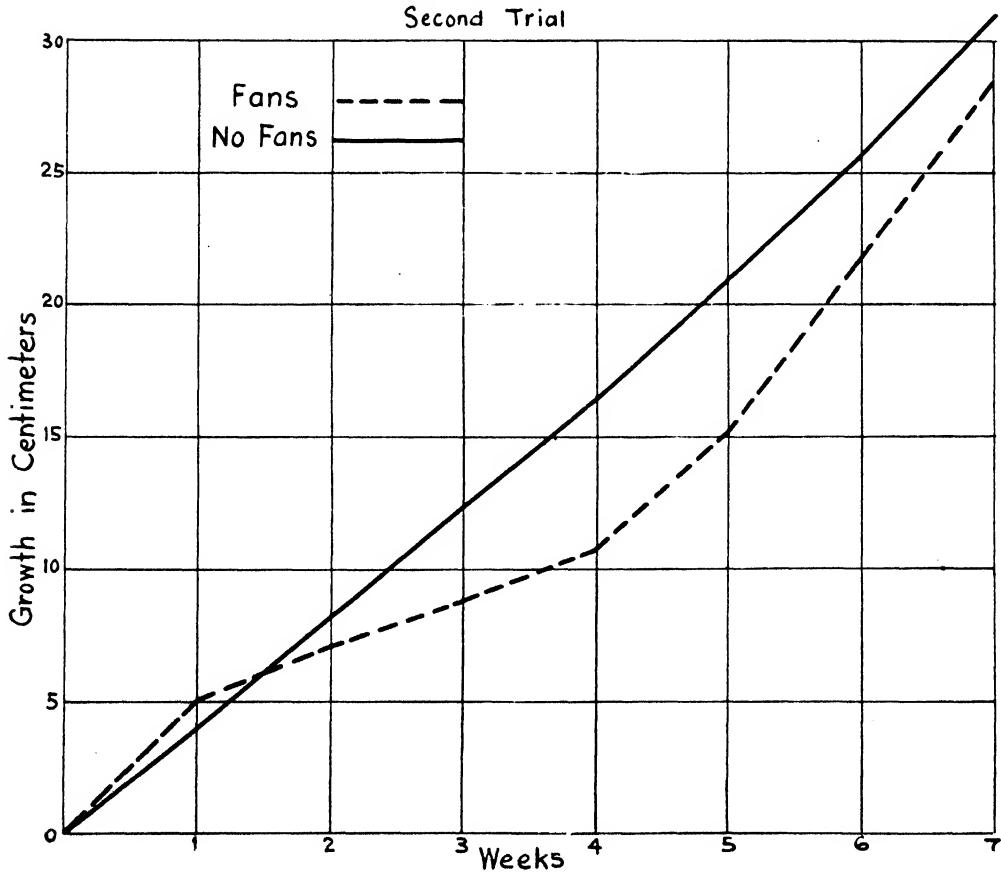


Fig. 2

**EFFECT OF WIND ON CANE GROWTH  
MOISTURE UNIFORM TO ALL POTS  
WEEKLY GROWTH**

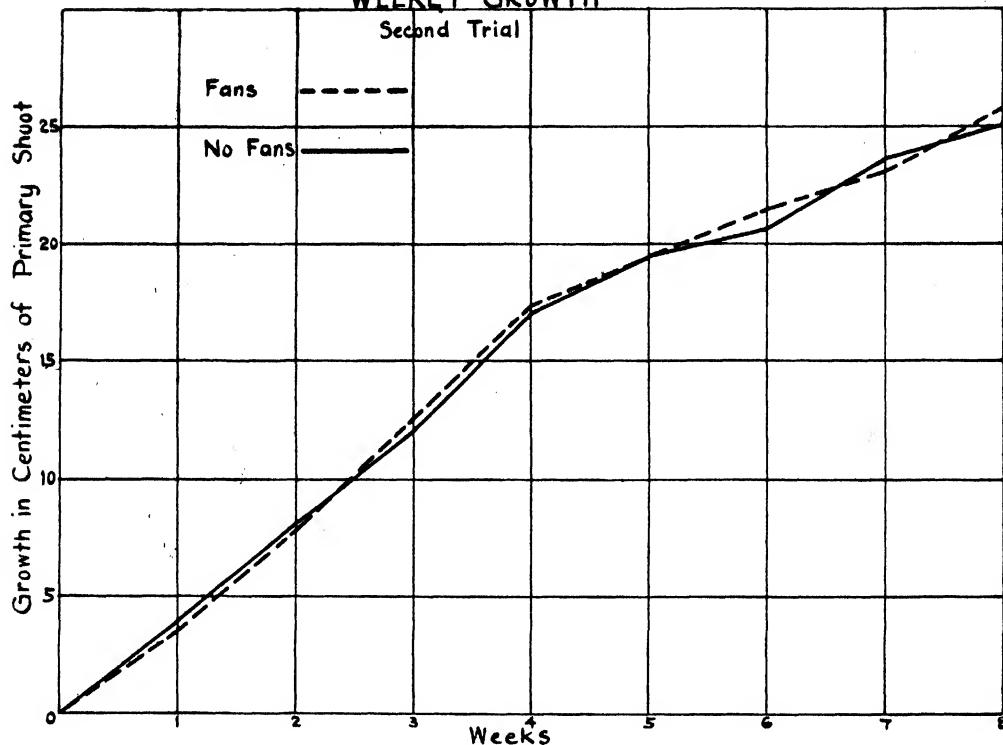


Fig. 3

soil near the stalks and may have hastened the emergence of the new shoots. Also, the constant shaking caused irritation, which may have stimulated stooling. (See Figs. 1, 2, 3.)

#### UNIFORM IRRIGATION SERIES

In this test uniform irrigation was applied to all pots, the aim being to provide the "no fan" pots with an optimum moisture content.

The test was conducted in two series of three pots for each treatment. Large galvanized iron pots were used for the test.

The results are summarized as follows:

#### TOTAL GROWTH OF PRIMARY SHOOT

	1st trial	2nd trial	Average per cent loss due to fans
Fans .....	8.3 inches	11.2 inches	20
No Fans .....	12.0 inches	12.3 inches	

#### GREEN WEIGHT OF ABOVE GROUND PORTION

	1st trial	2nd trial	Per cent loss in weight
Fans .....	8.9 ounces	6.5 ounces	35
No Fans .....	14.8 ounces	8.9 ounces	

From these tests we see that even moderate winds producing no appreciable physical damage to the leaves produce very substantial losses in weight. When the evaporation factor is eliminated by keeping an optimum moisture content in all pots, the indicated loss in this test is 14 per cent, but when the evaporation factor is added the loss in weight becomes 35 per cent, showing that for dry conditions winds become very important factors in checking the growth of sugar cane. (See Figs. 4, 5, 6, 7, 8.)

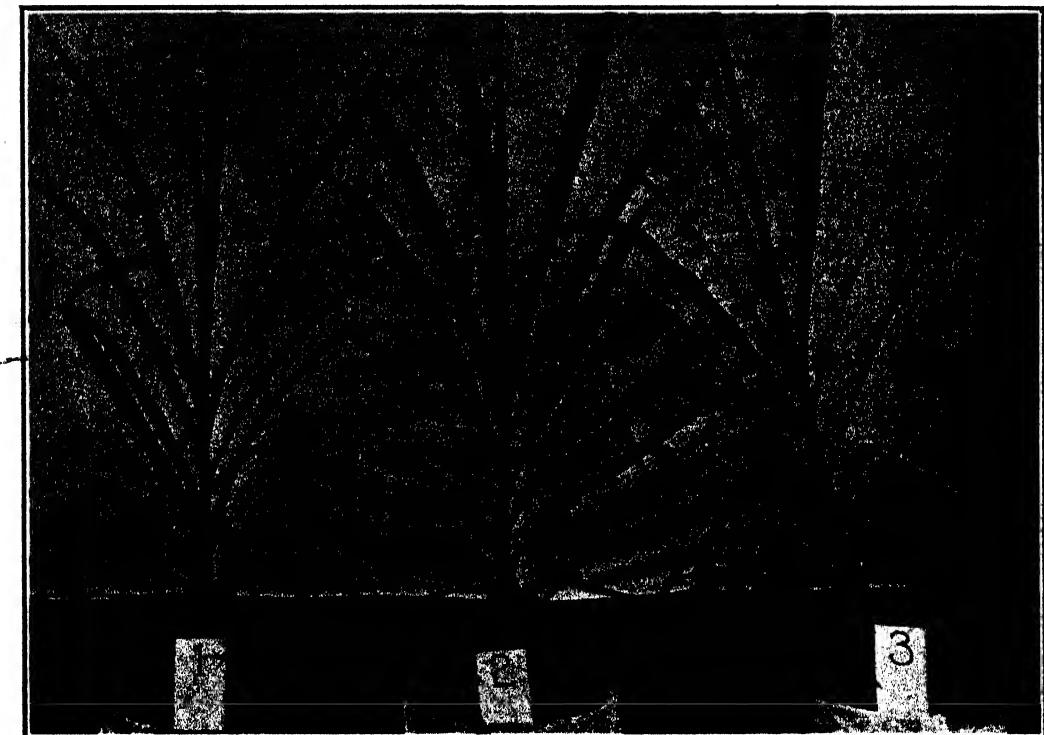


Fig. 4. Fans were placed in front of these plants in the hothouse and allowed to run continuously for seven weeks. Compare the shoot growth with Figs. 2 and 3. Irrigation uniform to all pots.



Fig. 5. These plants were allowed to grow in the hothouse with no wind blowing on them. The shoot growth is better than in the case of Fig. 1, but not as good as in Fig. 3. Irrigation uniform to all pots.

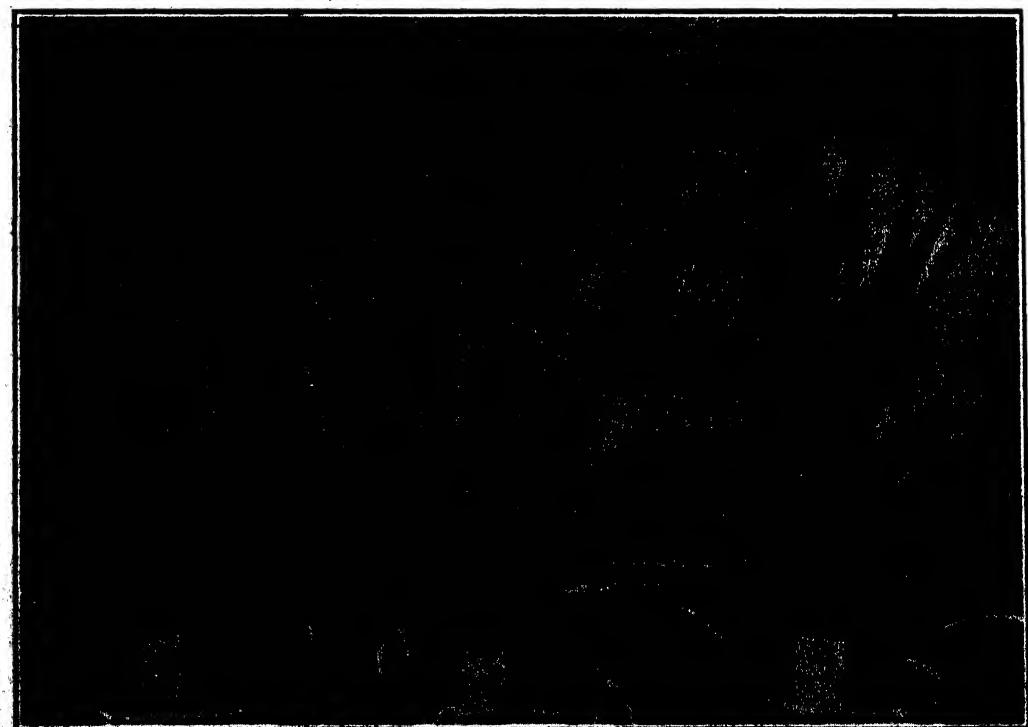


Fig. 6. These three plants were allowed to grow in the open under ordinary conditions. Although the primary stalks are not as tall as in Figs. 1 and 2, more shoots have developed.



Fig. 7. The effect of wind on cane growth at a constant moisture of 25 per cent on the dry basis. These plants were kept in the hothouse for 56 days and during this period electric fans were placed in front of the plants and were allowed to run continually.



Fig. 8. The effect of no wind on cane growth at a constant moisture of 25 per cent on the dry basis. The plants in this picture were kept in the hothouse for a period of 56 days, no wind being allowed to reach them.

## Replaceable Bases in the Soils of Central Maui

BY F. E. HANCE AND G. R. STEWART

### INTRODUCTION

In recent years there has been an increasing study of the base replacement occurring in soils that are treated with saline waters. The phenomenon of base replacement was first investigated comprehensively in 1850, by J. T. Way (9), in England. This work was undertaken in order to find the nature of the fixation which takes place when salts of ammonium, potassium or phosphoric acid are added to the soil. Way was able to show that this fixation was an actual chemical reaction between the clay of the soil and the fertilizing salt. In this reaction the base of the fertilizing material was absorbed by the clay and an equivalent amount of calcium was displaced from the soil colloid.

Later Hissink (4), in Holland, studied the effect that ocean water had upon the soil of tidal flats. When this land was reclaimed and brought under cultivation certain areas were found to be infertile. Hissink showed that this infertility was associated with the replacement of the calcium in the soil colloid by the sodium of the sea water. His work showed clearly that base replacement was a general phenomenon which involved the same type of interaction that Way had observed in the case of fertilizing salts.

Gedroiz (2), working in Russia, has investigated the base exchange which has taken place in the alkali soils of the Russian steppes. He has shown that base replacement always occurs in the clay or colloidal portion of the soil. Gedroiz demonstrated the effect of toxic concentrations of sodium upon soils of normal productivity and good physical texture. The result of such applications was to cause a gummy, deflocculated condition in the soil and this, he showed, was caused by the replacement of calcium by sodium.

Kelly (5), in California, has found the underlying cause of soil impermeability to be an excess of replaceable sodium. He states: "It now seems certain that some of the most difficult phases of the alkali problem of semi-arid regions are closely related to and indeed caused by the substitution of sodium for one or more of the bases normally present in replaceable form. There are two especially important effects produced by the substitution of sodium for the divalent bases, namely: (1) the granular structure of the clay materials becomes broken down with the resulting development of extreme impermeability; (2) sodium carbonate is formed as a result of hydrolysis."

The injurious effect of soluble salts in irrigation water has been observed in many semi-arid countries. Here in Hawaii, cane fields are, in some cases, necessarily irrigated with slightly saline artesian waters. This has occasionally resulted in some injury to cane crops, but so far we have not had to face an acute alkali problem. Work previously carried out by one of us (G. R. Stewart) clearly

indicates that this comparative freedom from injury is due to the appreciable calcium content of the pump waters.

It has been found on the mainland by Kelley and Thomas (6), and later by McGeorge (7), that the reclamation of saline soils could not be accomplished, solely, through the substitution of a good water for one containing soluble salts. The water of higher purity leached out the soluble sodium salts, but left the soil in a practically impermeable state. Such a condition caused the failure of the attempted reclamation. Upon planting crops in such deflocculated land it was found to be in a worse state for crop growth than it was when the soluble salts were present. This infertile condition, developed in the work carried on in California and Arizona, was found to be due to excessive amounts of replaceable sodium in the soil colloids. For those of our readers who care to follow a semi-technical discussion of the theory of base replacement we append the following summary:

#### THE THEORY AND MECHANISM OF BASE REPLACEMENT

A base may be defined in chemistry as the oxide or hydroxide of the alkali metals lithium, sodium, potassium, etc. The alkaline earth metals, magnesium, calcium, strontium, etc., are likewise basic. The term also includes the hydroxide of ammonium and the hydrides of other non-metals such as pyridine, phosphorus, etc.

Following the common convention we will use the term in this discussion to include only that portion of a compound or salt which imparts the alkaline characteristic to a true base. For example, the salt potassium chloride, which in itself is not alkaline in reaction, would be called a basic compound because the alkali metal potassium forms a part of its molecule.

A replaceable base may include the alkaline constituent of any of the salts of the basic elements or radicals mentioned above. Chlorides, sulphates, nitrates, carbonates, silicates, phosphates of potassium, sodium, ammonium, calcium and magnesium are the compounds which function in the more common replaceable base reactions. Under certain conditions aluminum, iron, manganese and hydrogen are also apparently found in the replaceable form.

In order that a base may become replaceable it must become detached from the parent salt and assume an unique position in the soil colloid. The only "change of state" in a compound which would favor the detaching phenomenon just mentioned without chemical reaction is the process of ionization. When the salt potassium chloride ionizes in aqueous solution, the bonds which hold its two component elements, K and Cl, in electrical neutrality, cease to maintain that union. As a result the potassium atom floats off as a separate entity, the potassium ion. It carries one extra positive charge of electricity. This entity or unit, in common with all the other bases, constitutes the elemental factor in base replacement. We have stated that the ion, potassium, carries a positive charge of electricity. The small particles of the soil colloid are charged with negative electricity. When brought in contact these oppositely charged particles unite by mutual attraction, the base

assuming a position on the surface of the infinitely small and united mass. The base, potassium, has now become a part of the colloidal soil complex. The attraction which holds it is peculiar in two respects: First, leaching with pure water in unlimited volume would not dislodge it; second, contact with a solution containing any other base would immediately result in a replacement in which the potassium would exchange places with the prevailing base of the solution. The process is reversible, the limiting conditions being a matter of concentration or dominance of any one base or group of bases, in the soil solution. When the exchange takes place the base leaving the soil colloid assumes the position of the exchanging element in the soil solution. To illustrate: Assume that the base calcium was in combination with the soil colloid as "replaceable calcium." Now, if a solution of sodium chloride passes down through the soil, calcium will be removed from the soil colloid and sodium will replace it. A solution of calcium and not sodium chloride now continues downward. The illustration, of course, is an extreme case.

The theory underlying the exchange process is stated by Hissink (3) as follows: "The exchangeable bases are located on the surface of the soil particles; in other words, they occur in the adsorbed condition. The cause of this adsorption is to be sought in the chemical attraction between the bases and the soil acids (clay and humus acids). When the soil is treated with water, a soil suspension is formed. A part of the surface molecules then become ionized, forming around the surface of the adsorbing clay and humus particles an electrical double layer. In the inner part of this double layer are found the anions of soil acids, in the outer part the cations  $H^+$ ,  $Mg^{++}$ ,  $Ca^{++}$ ,  $K^+$ ,  $Na^+$ , etc."

Gedroiz (2), Kelley (5) and Burgess (1) have shown that the physical and chemical properties and reactions of a soil are largely dependent upon the relationships existing between the various replaceable bases which may be present. These investigators have admirably presented the subject from the theoretical standpoint. They have, in addition, cited data from numerous practical applications of the principles involved and have made valuable recommendations as to corrective measures to employ in returning a salt-damaged soil to fertility.

#### EXPERIMENTAL

The present study is devoted to the attempt to ascertain if an unfavorable interchange of bases was associated with the failure of H 109 cane in certain limited areas in Central Maui. These poor spots were located in the fields of the Hawaiian Commercial and Sugar Company at Puunene, and ranged in size from 1/20 to 1/2 acre. The total area affected in the entire plantation was not large, as it would probably not exceed 35 or 40 acres. The poor cane, however, was notably stunted and in some cases died out completely. The immediate failure of the cane was found by Muir (8) to be associated with heavy infestations of several varieties of nematodes which attacked the roots. Following these nematode attacks the roots of the poor cane broke down and largely rotted away.

The areas of poor cane were clearly marked off from the surrounding good stools, and suggested the possibility of some soil difference existing in these locali-

ties. An unfavorable soil condition might conceivably, either affect the vitality of the cane so that the stools would be unable to resist nematode attacks, or might be conducive to an unusual development of nematodes in the poor areas.

Practically all the poor cane was located in fields which had been irrigated with pump water containing appreciable amounts of soluble salts. Samples of soils from many of the poor spots and from adjoining good portions of the fields were collected by one of us (G. R. Stewart), and by Hansson, of this Experiment Station. Analyses of the displaced soil solutions and of the soluble salts did not show any consistent differences between the good and poor soils.

The association of plant failure with unfavorable basic ratios in a diversity of soils and crops, throughout continental United States and Europe, suggested the desirability of applying a similar study to the infertile areas of Hawaiian soils. This decision was reached by the head of the department of chemistry, after careful consideration of the factors which, in his experience, indicated that base replacement was possibly one of several causes contributory to root failure in the segregated poor areas previously described.

It then remained to determine whether the replaceable bases present in the good and poor soils were sufficiently different to account for the infertility of the poor spots.

The replaceable bases were accordingly determined in both the surface soil and subsoil in a series of the good and poor portions of the fields of Hawaiian Commercial and Sugar Company. The determinations were carried out on the subsoil as well as the surface soil in order to obtain some information as to the depth to which base replacement would take place. We anticipated that if an unfavorable replacement of bases had occurred in these soils, it would consist in the partial or entire substitution of calcium by sodium. The data on a series of the typically good and poor soils from Puunene are given in Table I. The figures for replaceable bases are presented in three different forms: first, as the actual per cent of bases present in the soil; second, as the relative percentage of each of the four principal bases; third, as the ratio of replaceable calcium to magnesium. A careful study of our results showed, contrary to our expectation, that the content of replaceable sodium was not exceptionally high. In several cases, in fact, the replaceable sodium was present in larger amounts in the good than in the poor soils. We found, however, that one constant relationship did appear to exist between the good and poor areas. In all cases the good soils had a lower content of replaceable magnesium than was found in the adjoining poor soil. These unfavorable ratios of calcium to magnesium were more evident in the surface soil of the poor areas than in the subsoil.

The poor area sampled in Field 18, Hawaiian Commercial and Sugar Company, shows an extreme instance of a high content of replaceable magnesium. It will be seen that the ratio of calcium to magnesium in the poor soil was 0.95 calcium to 1.00 magnesium. In the soil where good cane was growing, a few feet distant, the ratio was 1.75 calcium to 1 magnesium.

TABLE I

Plantation	Field No.	Condition of Cane	Surface or subsoil			Cane variety	Surface bases in soil			Relative per cent of bases			Ratio Ca to 1 Mg	
			Ca	Mg	K		Ca	Mg	K	Na	Ca	Mg	K	
H. C. & S. Co.	18	Co. 4	Poor—roots almost dead	Surface	H 109	.13	.14	.09	.05	32	34	.22	.12	0.95
H. C. & S. Co.	18	Co. 4	Poor—roots almost dead	Subsoil	H 109	.19	.16	.13	.08	33	29	.22	.16	1.14
H. C. & S. Co.	18	Co. 4	Good cane	Surface	H 109	.16	.09	.10	.08	37	21	.23	.19	1.75
H. C. & S. Co.	18	Co. 4	Good cane	Subsoil	H 109	.16	.10	.13	.06	36	22	.29	.13	1.64
H. C. & S. Co.	E	Poor cane	Surface	H 109	.18	.16	.06	.08	38	33	.13	.16	1.15	
H. C. & S. Co.	E	Poor cane	Subsoil	H 109	.17	.15	.06	.08	38	32	.13	.17	1.20	
H. C. & S. Co.	E	Good cane	Surface	H 109	.19	.11	.07	.05	45	26	.17	.12	1.73	
H. C. & S. Co.	E	Good cane	Subsoil	H 109	.18	.12	.06	.07	42	28	.14	.16	1.50	
H. C. & S. Co.	7	Co. 2	Partly sick cane	Surface	H 109	.41	.05	.08	.04	80	11	2	7	7.30
H. C. & S. Co.	7	Co. 2	Good cane	Surface	H 109	.25	.026	.08	.03	79	8	2.5	10	9.90
H. C. & S. Co.	18	Co. 1	Poor cane	Surface	H 109	.22	.13	.12	.07	40	25	.22	.13	1.60
H. C. & S. Co.	18	Co. 1	Good cane	Surface	H 109	.24	.10	.08	.04	46	19	19	15	2.40
H. C. & S. Co.	2	Co. 43	Poor cane	Surface	H 109	.26	.12	.07	.06	51	23	14	12	2.20
H. C. & S. Co.	2	Co. 43	Good cane	Surface	H 109	.31	.10	.09	.07	55	17	16	12	3.30

In order to confirm these unusual results it was decided to determine the replaceable bases in a series of other soils from Central Maui, in which good and poor Lahaina cane was growing. The following soils were used:

1. A virgin soil from Field 96, Maui Agricultural Company. No cane was growing on this land.
2. Soil from a plant field of Lahaina cane, where excellent cane was growing. Field 96, Maui Agricultural Company.
3. Soil from a first ratoon field of Lahaina cane, where there was some evidence of failure. Field 95, Maui Agricultural Company.
4. Soil from an area of abandoned Lahaina cane. Field A, Company 27, Hawaiian Commercial and Sugar Company.

The determinations of replaceable bases on these soils are given in Table II. It will be seen that in the virgin soil the ratio of replaceable calcium to magnesium is 6.7 to 1. In the soil of the plant fields of Lahaina the ratio is 5.3 to 1. In the first ratoon field the ratio of calcium to magnesium was 3.4 to 1, while in Field A, where Lahaina cane was growing very poorly the ratio was 1.05 to 1. These data appear to confirm the previous observation regarding the unfavorable influence of a high content of replaceable magnesium. There are several points, however, which should be considered before such a conclusion is accepted. The three soils from the Maui Agricultural Company fields have not been treated with saline waters. The virgin soil has not received any irrigation and the other two soils have been irrigated with mountain water. We have no present evidence that Lahaina cane absorbs an exceptional quantity of calcium, so the higher ratio of replaceable calcium in the better soils may possibly be a matter of variation in the composition of the original soil. The association of a high content of replaceable magnesium with a poor condition of the cane is, however, extremely consistent.

In order to obtain more definite experimental evidence of the toxic effect of a high content of replaceable magnesium we have under way the following series of soil treatments. The first series consists of seven pots, each holding 61 pounds of soil, from the Makiki plots of this Station. This soil in its original state is a fertile soil with a high ratio of replaceable calcium to replaceable magnesium. Four pots, to be kept as controls, were leached, 15 gallons of distilled water per pot. The three remaining pots were first leached with 5 gallons of 1/10 normal solution of magnesium sulphate. This treatment was followed by leaching with 10 gallons of distilled water. The net effect of this treatment was to secure, in three pots, a soil with a high content of replaceable magnesium, but free from soluble magnesium sulphate. The four controls had the original high ratio of replaceable calcium to replaceable magnesium. Each pot of the entire series was subjected to the same leaching of the soluble soil nutrients by the treatment it had received.

The pots were each planted on February 3, 1927, with uniform three-eye seed pieces of H 109 cane, from which two eyes were removed. The effect of the replaceable magnesium has been apparent from the first appearance of the young shoots. The cane in the magnesium treated pots has been stunted and spindly. No secondary or tertiary shoots have appeared during the three months' growth, while the cane growing in the control pots sent out both secondary and tertiary

TABLE II

Plantation	Field No.	Condition of Cane	Surface or subsoil	Cane variety	Per cent bases in soil			Relative per cent of bases			Ratio Ca to 1 Mg	
					Ca	Mg	K	Na	Ca	Mg		
M. A. Co.	96	Virgin soil	Surface.....None .....	.33	.05	.08	.02	67	10	18	5	6.7
M. A. Co.	96	Plant cane.....Very good .....	Surface.....Lahaina .....	.33	.06	.09	.03	64	12	18	5	5.3
M. A. Co.	95	First ratoon.....Shows failure .....	Surface.....Lahaina .....	.26	.07	.08	.04	58	17	18	7	3.4
H. C. & S. Co.	A Co. 27	Very poor cane.....A Co. 27 .....	Surface.....Lahaina .....	.17	.16	.07	.06	37	35	15	13	1.05
H. C. & S. Co.	A Co. 27	Very poor cane.....Very poor cane .....	Surface.....Lahaina .....	.16	.14	.07	.06	37	32	17	14	1.15

shoots at an early date. The soil in the magnesium treated pots has undergone a notable change in texture and has become rubbery and impermeable. After heavy rains, puddles of water persist above the surface of the treated soils until it is removed by evaporation. Both rain water and irrigation have always passed rapidly through the controls.

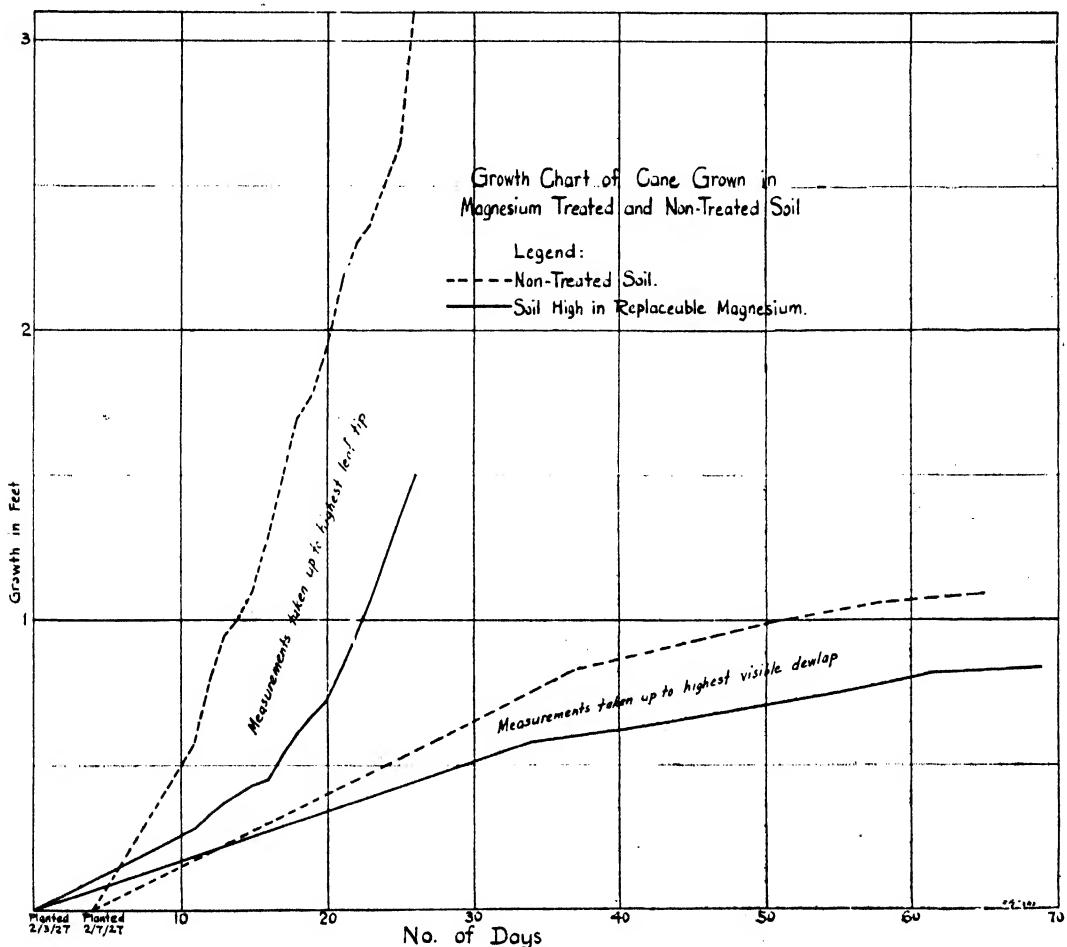


Fig. 1

Growth measurements have been made on the cane grown in the treated and untreated pots. The growth of the best control as compared to the best of the magnesium treated plants is shown in Fig. 1. Photographs of the growth made in typical pots at monthly intervals are shown in Figs. 2 and 3.

On May 3, the entire plants were removed from 1, the untreated control, and from 2, the magnesium treated pot from which growth measurements had been taken during the three months' interval. Fig. 4 is a photograph of these two specimens which was taken soon after removal from their respective pots. The roots of the cane grown in the environment of high replaceable magnesium are badly stunted and deficient in secondary roots. The effect of the cutting off of atmospheric air by the impermeable soil is shown by the abnormal bleaching and whitening of the entire root system. The failure of secondary or tertiary shoots



Fig. 2. H 109 cane planted February 3, 1927. Pots 1, 3 and 5 are magnesium treated; pots 2 and 4 are controls. Photographed March 7, 1927.



Fig. 3. H 109 cane, showing the second month's effect of growth in untreated and in magnesium treated soils. The end pots are magnesium treated. The water, which may be observed in the illustration, remained after a rain occurring three days previously. The center pots are controls. Photographed April 4, 1927.

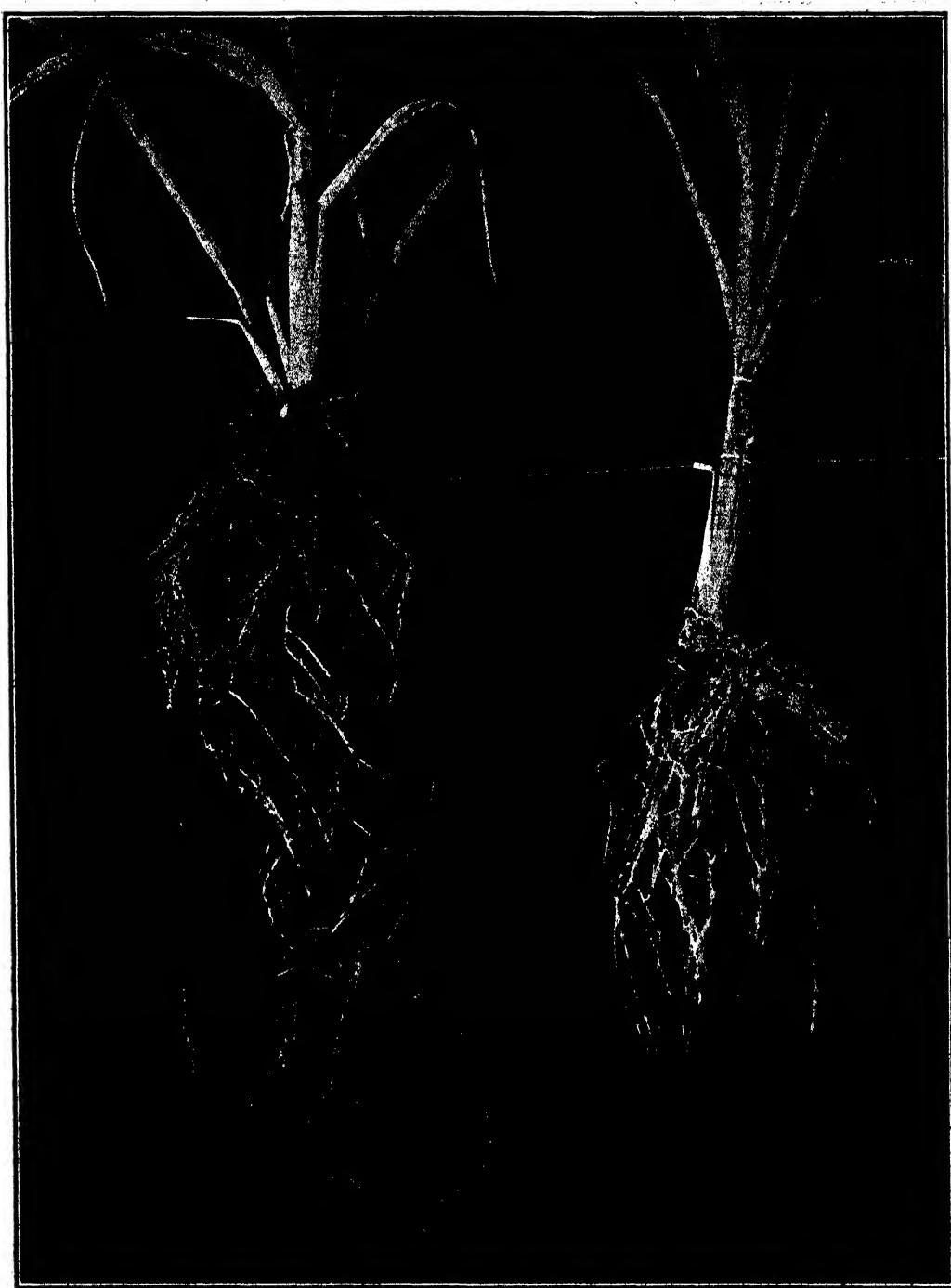


Fig. 4. Showing the effect of three months growth of H 109 cane in untreated Makiki soil (left), and in magnesium treated Makiki soil (right).

to appear above ground may also be observed in the illustration. The plant grown in the untreated soil is normal in all respects.

The condition of the cane growth in other magnesium treated soils of this experiment was found to be more abnormal than the specimen photographed. This naturally follows since only the best growths of both controls and magnesium treated soils were selected for measurement and comparison. The toxic effect of the magnesium treatment, upon cane grown in this soil, is clearly indicated.

We have treated the soil in the magnesium pots with calcium nitrate in an attempt to restore the soil to its original condition. The attempt at reclamation consisted of passing 5 gallons of  $\frac{5}{8}$  normal calcium nitrate solution through each pot of magnesium treated soil. This operation should bring about replacement of the magnesium by the calcium of the calcium nitrate solution. To remove all soluble calcium and magnesium nitrates each pot was subjected to a leaching with 10 gallons of distilled water. The pots are now planted to H 109 cane to test the efficiency of the reclamation.

We have another series of experiments under way in which we are using both good and poor soils from the fields of the Hawaiian Commercial and Sugar Company. In this series we have treated some of the good soils with soluble salts of magnesium, in order to study the harmful effect of this base, and have also treated the poor soils to try and remove the replaceable magnesium. This series was started at a later date (March 29) than the first experiment.

The preliminary indications are that the good soils from Puunene are not as readily flocculated as the soil from the Makiki plots. The impermeability of the soil became evident not immediately, as in the case of the Makiki experiment, but only after the seed pieces had been planted and one heavy irrigation had been made. We attribute this to the high granular condition of the soil and its failure to pack sufficiently after planting to enable the newly imparted and undesirable physical condition to become manifest. This conclusion is justified by the four-inch settling which has since occurred and the appearance of the rubbery condition which characterized the magnesium treated Makiki soil. The cane growing in this soil is suffering from the magnesium treatment the soil received, the damage being very pronounced at this writing (May 10).

There is every indication that the treatment of the poor soil with calcium nitrate solution has notably improved its condition and promises to be a feasible method of reclamation.

#### DISCUSSION

The above results appear to us to indicate that, in the soils of Central Maui, which we have investigated, the occurrence of a high content of replaceable magnesium in certain poor areas is related to the partial failure of H 109 cane in these spots. The present report is to be regarded as a progress report on this investigation. Hence we do not wish as yet to attempt to evaluate the various unfavorable influences which have contributed to the final failure and destruction of the cane roots. Nematode injury has been closely associated with the actual root destruction. Fungi or bacteria would unquestionably follow the nematodes and

would play some part in the breakdown of the roots. Cooperative experiments with the other departments of the Station will be necessary before we can attempt an accurate analysis of the various factors affecting cane growth in these poor spots. As a preliminary we plan certain remedial chemical treatments which should furnish excellent locations for the study of the effect of the biological factors influencing root development.

These remedial treatments will be as follows:

(1) The replacement of magnesium and sodium in the soil of the poor areas by saturating the irrigation water with calcium sulphate. We believe this may be done by installing a baffled box in the supply ditch with a series of pockets which should be partly filled with powdered gypsum. Such a treatment would not preclude the use of pump water, if that has been the usual practice. Care must be observed, however, to see that the supply of gypsum is replenished so that there may always be an adequate excess of calcium in solution. This base must be present in decidedly larger amounts than all other bases present in the water. If this method gives a saturated solution of gypsum, the water entering the field will contain one pound of calcium sulphate in every 50 gallons of water, which should cause calcium replacement in the worst soils we have thus far examined.

(2) In severe cases of magnesium or sodium injury a treatment of calcium nitrate should be worked into the surface soil before the water saturated with calcium sulphate is applied. This will insure a sufficient excess of soluble calcium over other bases at the beginning of the attempted reclamation. A preliminary determination of the replaceable bases present in the soil will indicate the amount of calcium salts which it will be necessary to apply. Even should the amounts of calcium nitrate be in excess of the immediate nitrogen requirement of the cane crop, previous work of one of us (G. R. Stewart) has shown the high tolerance of H 109 cane for heavy nitrate applications.

(3) It is generally desirable to apply some form of organic material after soil treatments which involve leaching through excessive irrigation. The organic residues will increase the soil colloids and assist in retaining soil moisture in the root zone. Mud press is particularly desirable as a source of organic matter because in addition it supplies an appreciable application of lime. Where it is available and can be applied to fallow land, molasses can be used both as a source of organic matter and potash. Sulphur and stable manure will also constitute a valuable treatment for many soils which are naturally alkaline and contain an excess of calcium carbonate.

#### SUMMARY

(1) Chemical examination of the soils from a series of infertile areas in Central Maui has shown that these soils contain a higher content of replaceable magnesium than is found in adjoining fertile land.

(2) Pot treatments of good and poor soils indicate that the presence of this excess of replaceable magnesium in the poor soils may be associated with the partial growth failure which has occurred.

(3) The relationship of this replaceable magnesium to biological conditions in the soil remains to be determined.

(4) Possible remedial treatments for an excess of replaceable magnesium have been indicated by our work and will shortly be tried in the field.

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## A Generic List of the Spear-Bearing Nematodes With a Revised Dichotomous Table

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By F. MUIR, GERTRUDE HENDERSON AND R. H. VAN ZWALUWENBURG

Since the generic table of spear-bearing nematodes was published in *The Hawaiian Planters' Record*, October, 1926, further specimens and literature have come to hand enabling us to enlarge and revise that work. The table presented herewith is mainly based upon literature and must not be considered as final, but it is an improvement upon the former. It is published as a help towards identifying the spear-bearing nematodes found in Hawaii. In cases of uncertainty the same genus has been placed in two divisions.

Of the thirty-five genera considered in the list most of them belong to the true hollow spear-bearers, Dorylaimidae and Tylenchidae of many authors, while a few would come into the Diphtherophoridae. They roughly come under Tylen-

chidae of Micoletzky. Forms such as *Campydora*, *Onchium* and *Onchulella* have not been included as they evidently have a solid tooth and not a hollow spear.

Baylis and Daubney in their useful "Synopsis of the Families and Genera of Nematoda" have accepted *Vibrio tritici* as the type of *Anguillulina* Gervais and van Beneden. This would then supersede *Tylenchus*, both as a generic and family name. Even if this be correct we consider the change is undesirable as *Tylenchus* is a large genus having a large literature and in recent years has become known in economic work. It is better to treat this case as one for *nomina conservanda*.

A great deal of work has yet to be done before this matter of classification and synonymy of these animals can be satisfactorily settled. At present there are two main classifications, one taking the structure of the spear as of chief importance, the other taking the structure of the oesophagus. We have used the former. The question of synonymy in many cases is a personal affair, as the information at present available is not sufficient to judge by. The same can be said as to what should be considered as a genus or subgenus. In the dichotomous table and list those names considered as generic are given under numbers, those considered as subgeneric under letters. The genera at present known to occur in Hawaii are printed in heavy type.

*Tylencholaimus aequalis* Cobb does not appear to be congeneric with *Tylencholaimus mirabilis* de Man, so it has been separated in the table, but a new name has not been given to it.

#### LIST OF GENERA AND SUBGENERA OF SPEAR-BEARING NEMATODES

1. **Actinolaimus** Cobb 1913, Jour. Wash. Ac. Sci. 3, p. 439. Orthotype *radiatus* Cobb.
2. **Aphelenchoïdes** Fischer 1894, Ber. d. phys. Lab. d. landw. Inst. Halle, Dresden, III (1), p. 1, Haplotype *kuhnii* Fischer.  
This is not mentioned by Micoletzky in his Die freilebenden Erd-Nematoden. The literature is not available so it cannot be placed in the table.
3. **Aphelenchulus** Cobb 1920, One Hundred New Nemas (Waverly Press), p. 301. Haplotype *mollis* Cobb.
4. **Aphelenchus** Bastian 1865, Tr. Linn. Soc. Lond, XXV, p. 93, 121. Logo-type *avenae* Bastian.
- (a) *Chitinoaphelenchus* Micoletzky 1922. Arch. f. Naturg. 87, Abt. A, H. 8, p. 119, H 9, p. 586. Type *ormerodis* Ritzema—Bos.
- (b) *Paraphelenchus* Micoletzky 1922, t. c. p. 603. Type *pseudoparietinus* Mic. The females of this genus are difficult to separate from *Tylenchus*.
5. **Archionchus** Cobb 1913, Jr. Wash. Ac. Sci. (3), p. 438. Haplotype *perplexans* Cobb.
6. **Atylenchus** Cobb 1913, Jr. Wash. Ac. Sci. (3), p. 437. Haplotype *decalineatus* Cobb.
7. **Brachynema** Cobb 1893. Nematode worms found attacking sugar cane. New South Wales Dept. Agric., p. 34. Haplotype *obtusa* Cobb.  
Name preoccupied by Brachynema Fieb, 1861, Hemiptera. Unable to place this genus; Baylis and Daubney suggest it may be near *Tylencholaimus*.

8. **Deontolaimus** Man 1880. Tijdschr. Nederl. dierk. Vereen. Leiden 3. Haplotype *papillatus* Man.
9. **Diphtherophora** Man 1880. t. c. p. 62. Haplotype *communis* Man.  
Syn. *Chaolaimus* Cobb 1893. Nematode worms found attacking sugar cane. N. S. W. Agr. Dept., p. 44. Haplotype *pellucidus* Cobb.
10. **Dolichodorus** Cobb 1914, Tr. Am. Micr. Soc. 33, p. 94, Haplotype *hetercephalus* Cobb.
11. **Dorylaimus** Dujardin 1845, Hist. Nat. des helm. ou vers intest., Paris, p. 230. Logotype probably *stagnalis* Dujardin 1845.  
Syn. *Antholaimus* Cobb 1913, Jr. Wash. Ac. Sci., p. 440. Haplotype *truncatus* Cobb.  
Syn. *Nygolaimus* Cobb 1913, Jr. Wash. Ac. Sci. (3), p. 441. Haplotype *pachydermatus* Cobb.
- (a) *Axonchium* Cobb 1920, One Hundred New Nemas (Waverly Press), p. 305. Haplotype *amplicolle* Cobb.
- (b) *Discolaimus* Cobb 1913. Jr. Wash. Ac. Sci., p. 439. Haplotype *texanus* Cobb.
- (c) *Dorylaimellus* Cobb 1913, Jr. Wash. Ac. Sci. 3, p. 440. Haplotype *virginianus* Cobb.
- (d) *Doryllium* Cobb 1920. One hundred New Nemas (Waverly Press), p. 303. Haplotype *uniforme* Cobb.
- (e) *Longidorus* Micol. 1922. Arch. f. Naturg. 87, Abt. A, H. 9, pp. 442, 458, 527. Type *elongatus* Man, 1876.
12. **Ecphyadophora** Man 1921, Capit. Zool. I, p. 35. Haplotype *tenuissima* Man. This genus cannot be placed on account of incomplete description.
13. **Eutylenchus** Cobb 1913, Jr. Wash. Ac. Sci., p. 437. Haplotype *setiferus* Cobb.
14. **Heterodera** Schmidt 1871, Zeitsch. d. ver. f. Ruben-Indust. in Zollverein, XXI, pp. 1-19. Haplotype *schachtii* Schmidt 1871.  
Syns. *Caconema* Cobb 1924, Jour. Parasit. XI, p. 118. Haplotype *radicicola* Greef 1872.  
*Heterobolbus* Railliet 1896. Rec. Med. Vet. Paris, LXXIII, p. 161. New name for *Heterodera*.  
*Meloidogyne* Goldi 1889, Zool. Jahrb. Jena. IV, p. 262. Orthotype *exigua* Goldi.  
If *radicicola* and *schachtii* are not congeneric and if *exigua* is congeneric with *radicicola*, then *Meloidogyne* Goldi must take precedence over *Caconema*.
15. **Hexatylus** Goodey, 1926. Jour. Helmin. IV, p. 27. Haplotype *viviparus* Goodey.
16. **Hoplolaimus** Daday 1905, Zoologica, Stuttgart XVIII, p. 62. Haplotype *tylenchiformis* Daday.  
Syn. *Criconema* Hofmanner and Menzel 1914, Zool. Anz. XLIV, p. 88. Logotype probably *Eubostrichus guernei* Crete, 1889.  
Syn. *Iota* Cobb 1913, Jr. Wash. Ac. Sci., p. 437. Orthotype *squamosa* Cobb 1913.

- Syn. *Ogma* Southern 1914, Pro. Roy. Irish Ac. Dublin, XXXI, (3), p. 66.  
 Haplotype *murrayi* Southern.
- If *Iota* has "retrorse scales or bristles" then it is distinct from *Hoplolaimus*, but if it only has reticulations then it is probably the same, as in Hawaiian specimens the rings often break up and form reticulations on the lateral surfaces.
17. **Iotonchium** Cobb 1920, One Hundred New Nemas (Waverly Press), p. 302.  
 Haplotype *Tylenchus imperfectus* Butschli, 1876.
  18. **Isonchus** Cobb 1913, Jr. Wash. Ac. Sci. 3, p. 439. Orthotype *radiciculus* Cobb.
  19. **Myenchus** Schuberg and Schroeder 1904, Verh. d. Naturh.—med. Ver. zu Heidelb. n. F. VII, p. 629-632. Haplotype *bothryophorus* Schuberg and Schroeder. The position of this parasitic genus is uncertain.
  20. **Myoryctes** Eberth 1863. Ztschr. f. wissenschaftl. Zool., Leipzig, XII, p. 530.  
 Haplotype *weismanni* Eberth. The position of this parasitic genus is doubtful.
  21. **Nemonchus** Cobb 1913, Jr. Wash. Ac. Sci. 3, p. 438. Haplotype *galeatus* Cobb.
  22. **Paratylenchus** Micoletzky 1922, Arch. f. Naturg. 87, Abt. A, H. 8, 9, pp. 119, 605. Haplotype *bukowinensis* Mic.
  23. **Pharetrolaimus** Man 1921, Capit. Zool., I, p. 42. Haplotype *sagittifer* Man. The oesophagus of the genus is not described. It may come next to *Xiphinema* or *Aphelenchus*.
  24. **Psilenchus** Man 1921, Capit. Zool., I, p. 36. Haplotype *hilarulus* Man.
  25. **Trichodorus** Cobb 1913, Jr. Wash. Ac. Sci. 3, p. 441. Haplotype *obtusus* Cobb.  
 Syn. *Leptonchus* Cobb 1920. One Hundred New Nemas (Waverly Press), p. 304. Haplotype *granulosus* Cobb.
  26. **Triplonchium** Cobb 1920. One hundred New Nemas (Waverly Press), p. 300. Haplotype *cylindricum* Cobb.
  27. **Tylencholaimellus** M. V. Cobb, 1915. Tr. Amer. Micr. Soc. XXXIV, p. 28.  
 Haplotype *diplodorus* M. V. Cobb.
  28. **Tylencholaimus** Man 1876. Tijds. d. Nederl. dierk. Vereen. Deel 2, p. 119.  
 Logotype *mirabilis* Butsch. 1873.
  29. **Tylencholaimus** Cobb not de Man, 1918. U. S. D. A. Tech. Circ. I. Estimating nema popul. soil. Haplotype *acqualis* Cobb.
  30. **Tylenchorhynchus** Cobb 1913. Jr. Wash. Ac. Sci. 3, p. 438. Haplotype *cylindricus* Cobb.
  31. **Tylenchulus** Cobb 1913. Jr. Wash. Ac. Sci. 3, p. 287. Orthotype *semi-penetrans* Cobb.
  32. **Tylenchus** Bastian 1865. Tr. Linn. Soc. Lond. 25 (2), p. 125. (On page 94 misspelled as *Tylelenchus*.) Logotype *davainii* Bast. 1865.  
 Syn. *Parasitylenchus* Micoletzky 1922, Arch. f. Naturg. 87, Abt. A, H. 9, p. 545, footnote. Type *Tylenchus contortus typographi* Fuchs 1915.
  - (a) **Chitinotylenchus** Micoletzky 1922. Arch. f. Naturg. 87, Abt. A, H. 8, p. 119, H 9, pp. 546, 575. Type *paragracilis* Micoletzky.

33. **Tylolaimophorus** Man 1880, Tijd. d. Nederl. dierk. Vereen. Deel 5, p. 63, Orthotype *typicus* Man.
34. **Tylopharynx** Man 1876. Tijd. d. Nederl. dierk. Vereen. Deel 2, p. 116. Haplotype *striata* Man.
35. **Xiphinema** Cobb. 1913. Jr. Wash. Ac. Sci. 3, p. 436. Haplotype *americanum* Cobb.

DICHOTOMOUS TABLE OF THE GENERA OF SPEAR-BEARING NEMATODES

1. 48. Spear with base distinctly enlarged, consisting of either a single structure or of three or more structures more or less amalgamated.
2. 9. Spear consisting of three pieces, either separate or fused together at their distal extremities (rather indefinite).
3. 4. Spear consisting of three separate spines; kappchen (spear cap) present; oesophagus muscular, without bulb..... *Diphtherophora*.
4. 3. Spear consisting of three pieces fused together apically, base trifurcate or knobbed.
5. 6. Base of spear with three distinct swellings; oesophagus sometimes with median bulb ..... *Tylopharynx*.
6. 5. Spear split at base; oesophagus without median bulb.
7. 8. Spear with a kappchen (spear cap); amphids transversely oval..... *Tylolaimophorus*.
8. 7. Spear without a kappchen (spear cap); amphid stirrup shape..... *Tylencholaimus aequalis* Cobb.
9. 2. Spear consisting of one piece or of three pieces fused together from apex to base, base distinctly enlarged.
10. 11. Cuticle with very distinct rings or reticulations, broken or complete; spear strong and generally long (1/6 to 1/9 of body length)..... *Hoplolaimus*.
11. 10. Cuticle without distinct rings or reticulations.
12. 13. Spear short, thick, apparently attached to the side of the wall of pharynx, apex slightly enlarged; base swollen and oblique..... *Archionchus*.
13. 12. Spear free except at base, not enlarged at apex, base not oblique.
14. 15. Spear massive, distinctly divided into two parts, the anterior half being chitinous, the basal half transparent, the base not very distinctly enlarged. Head with a strong chitinous framework..... *Nemonchus*.
15. 14. Spear not so massive and not divided into two parts.
16. 19. Oesophagus without a median bulb.
17. 18. Base of spear produced into six lobes, spear short; oesophagus considerably swollen behind nerve ring..... *Hexatylus*.
18. 17. Base of spear produced into three lobes.
19. 20. Spear trifurcate at base or basal half considerably larger than distal half..... *Tylencholaimus aequalis* Cobb.
20. 19. Spear bulbous at base, the enlarged basal part being much less than half.

21. 22. Oesophagus very slender in middle, swollen anteriorly and posteriorly. Spear long and slender; kappchen (spear cap) present .. ***Paratylenchus***.
22. 21. Oesophagus not so distinctly slender in middle.
23. 26. Spear very short, in some almost vestigial.
24. 25. Oesophagus with an elongate posterior bulb; spear obliquely truncate anteriorly ..... *Tylencholaimellus*.
25. 24. Oesophagus cylindroid or faintly cephaloboid; spear nearly vestigial, apex acute ..... *Aphelenchulus*.
26. 23. Spear long or very long.
27. 28. Spear very long. Amphids small, obscure..... *Tylencholaimus* Man. ***Xiphinema***.
28. 27. Spear much shorter; amphids large, oval, deep, often protruded (especially when fixed in Flemming's solution) .. *Triplonchium*, *Decontolainus*.
29. 16. Oesophagus with a median bulbous swelling.
30. 31. Spear with a kappchen (spear cap), or the anterior half of the pharynx heavily chitinized ..... *Tylenchorhynchus*.
31. 30. Spear without a kappchen (spear cap), or the anterior half of pharynx not heavily chitinized.
32. 35. Anteriorly with four large, distinct bristles or setae; (bursa trapezoid).
33. 34. Cuticle prominently and longitudinally striate; male without bursa or very obscure ..... *Atylenchus*.
34. 33. Cuticle not prominently and longitudinally striate; male with distinct bursa ..... *Eutylenchus*.
35. 32. Anteriorly without setae or bristles.
36. 37. Excretory pore behind the middle of body; adult female greatly enlarged; median bulb not well developed..... *Tylenchulus*.
37. 36. Excretory pore before middle of body.
38. 39. Oesophagus behind bulb indistinct, appearing as if the intestine joined the bulb; glands separate from oesophagus on dorsal surface as "salivary glands"; males without bursa... ..... *Aphelenchus*.
- a. b. Anterior end with a chitinous ornamentation..... *Chitinoaphelenchus*.
- b. a. Anterior end without such ornamentation.
- c. d. Oesophagus distinctly separated from the intestine..... *Paraphelenchus*.
- d. c. Oesophagus not so distinctly separated from the intestine..... *Aphelenchus*.
39. 38. Oesophagus behind bulb distinct.
40. 41. Amphids large, oval, deep, often protruded (especially when fixed in Flemming's solution) ..... *Triplonchium*.
41. 40. Amphids unknown or small, more obscure, not protruded.
42. 43. Males without bursa or only rudimentary; adult females greatly swollen and incapable of movement..... *Heterodera*.
43. 42. Males with bursa; adult females not greatly swollen, capable of movement.
44. 45. Bursa lobate; spear very long ( $\frac{1}{3}$  to  $\frac{1}{5}$  length of oesophagus)..... *Dolichodorus*.

45. 44. Bursa plain; spear smaller.
46. 47. Spear moderate,  $\frac{1}{5}$  to  $\frac{1}{3}$  the length of oesophagus..... *Tylenchus*.  
 a. b. Head without a chitinous cap..... *Tylenchus*.  
 b. a. Head with a chitinous cap..... *Chitinotylenchus*.
47. 46. Spear minute length  $\frac{1}{4}$  to  $\frac{1}{5}$  the width of head..... *Iotonchium*.
48. 1. Spear composed of a single hollow piece, slightly and gradually enlarged to base, base truncate, not swollen or enlarged or produced into prongs.
49. 52. Oesophagus with a distinct median bulb; excretory pore present.
50. 51. Male bursa supported by prominent ribs..... *Isonchus*.
51. 50. Male bursa without ribs..... *Psilenchus*.
52. 49. Oesophagus without a distinct median bulb; excretory pore absent.
53. 54. Anterior portion of pharynx large, cup shape, supported by radiating chitinous ribs or other structures, sometimes beset with small teeth ..... *Actinolaimus*.
54. 53. Anterior portion of pharynx small, without such armature.
55. 56. Spear very long, slender and flexible..... *Trichodorus*.
56. 55. Spear thick, not flexible, proportionally shorter..... *Dorylaimus*.  
 a. b. Spear long, needle-like..... *Longidorus*.  
 b. a. Spear not so long and needle-like, more spine-like.  
 c. d. Spear gradually enlarging from middle to base..... *Doryllium*.  
 d. c. Spear without such enlargement at base.  
 e. f. Oesophagus considerably swollen anteriorly..... *Dorylaimellus*.  
 f. e. Oesophagus not swollen at the anterior end.  
 g. h. Lip region discoid, expanded, sucker-like..... *Discolaimus*.  
 h. g. Lip region not expanded.  
 j. k. Oesophagus cylindrical or slightly enlarged posteriorly, distinctly divided into two portions by a constriction..... *Axonchium*.  
 k. j. Oesophagus distinctly larger posteriorly than anteriorly; without a constriction..... *Dorylaimus*.

#### THE THREE COMMON SPECIES OF NEMATODES IN SUGAR CANE IN HAWAII

The three species of nematodes which play the chief part in the nematode problem of sugar cane in Hawaii are: *Heterodera schachtii*, *Heterodera radicicola*, and *Tylenchus similis*.

The following characters are employed to distinguish the three species:

#### *Heterodera schachtii*:

*Male*: Head shows a distinct six lobed chitinous cap; spear comparatively large and stout; striations very distinct; bursa absent or only rudimentary; testes single.

*Female*: Head shows a distinct six lobed chitinous cap; spear large and stout; striations very distinct; vulva in the slender female is near the posterior end. The gravid female is greatly swollen and is flask-shaped.

*Larvae*: The larval forms possess the same characteristics as distinguish the females. Confusion often arises between the young forms of *Heterodera schachtii*; *Heterodera radicicola* and *Tylenchus similis*. The larvae of *Heterodera schachtii* may be distinguished from *Heterodera radicicola* by the six lobed chitinized head piece and by the fact that they are noticeably less slender than corresponding forms of *Heterodera radicicola*.

The situation of the developing gonads, when visible, will distinguish them from *Tylenchus similis*. In *Tylenchus similis* the gonads are much nearer the middle than in *Heterodera schachtii*.

#### *Heterodera radicicola*:

*Male*: Head without chitinous cap, but divided into three distinct regions, in end view a median subquadrate and two lateral oval regions; spear comparatively slender; striations less distinct; bursa absent or very rudimentary; testes paired.

*Female*: Head as in male; spear as in male; striations as in male; vulva near the posterior end in the slender female; gravid female is greatly swollen and is flask-shaped.

*Larvae*: The larval forms possess the same characteristics as the female. They may be distinguished from the larvae of *Heterodera schachtii* and *Tylenchus similis* by the head characters. They are more slender than the larvae of *Heterodera schachtii* and differ from *Tylenchus similis* in the situation of the gonads.

#### *Tylenchus similis*:

*Male*: Head rounded and plain, without chitinous cap and constricted off by a distinct suture very similar to some species of *Aphelenchus*. Spear weaker than in the female and sometimes rudimentary; striations distinct; bursa present; testes single.

*Female*: Head with a distinct six lobed chitinous cap; spear well developed; striations distinct; vulva near the middle; gravid females are never swollen.

*Larvae*: The larval forms possess the same characteristics as the female. The head shows a strongly chitinized cap. The gonads are often distinct and are situated near the middle.

In short, the two species of *Heterodera* may be distinguished by the different head characters.

*Heterodera schachtii* and *Tylenchus similis* are usually more difficult to separate. In the male, the presence or absence of the bursa and the marked differences of the heads distinguish them. In the females, the position of the vulva, and in the gravid stages the swollen condition of the female *Heterodera schachtii* form good characters for separation.

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## The Preservation of Cane After Cutting From the Stool

By F. E. HANCE

In the crossing of various varieties of cane it frequently becomes desirable to remove from the stool a number of tasseled stalks from a distant location to be placed adjacent to other varieties during the period of pollination.

Success is dependent not only in maintaining vigor and turgidity in the detached stalks for the duration of the experiment, but in securing an uninterrupted development in the upper extremities of the plant.

U. K. Das, of the agricultural department at this Station, has found that immersion of the cut stalk in a .03 per cent solution of sulphurous acid will, in many cases, preserve the cane for periods as long as five weeks. Das experimented with many solutions of acids, salts and organic preservatives. He found that the sulphurous acid solution was the only medium which, in his experience, gave reasonably satisfactory results in maintaining the life of the detached cane. When a freshly cut stalk is placed in water, evidence of wilting will usually be observed in about fifteen to twenty hours. A brownish-red bacterial growth will then be found in small amounts on the cut end of the immersed stalk. The bacterial formation rapidly spreads over the entire cut surface, closing the vascular bundles and the cane quickly succumbs from lack of moisture. The presence of minute amounts of sulphurous acid inhibits this bacterial formation.

The studies of D. M. Weller, of the pathology department, seem to indicate that sulphurous acid may possibly have a detrimental effect on the vitality of the pollen.

It appeared desirable, then, to seek an immersion medium which would maintain vitality in the cut plant without imparting to it any appreciable soluble or volatile toxins.

Many experiments were conducted over a period of several months. The author was ably assisted in this work by F. G. Teho. We were unable to find any solutions which were entirely satisfactory for the preservation of the cut stalk by immersion of the butt.

We found, however, that an acid solution of sodium nitrite would preserve the cane over a period of several weeks. The nitric oxide, resulting from the decomposition of the nitrite salt, maintained a turgid, green condition, whereas the cane immersed in dilute sulphurous acid soon became yellow.

The table contains a memorandum of some of the solutions employed, with brief comments on the results obtained.

We felt that more satisfactory results could be developed if conditions were imposed which more nearly followed the natural functions of the growing cane.

Accordingly, our efforts were directed in devising a simple method of causing the cut stalk to send out roots into a nutrient medium. Our aim was to supply moisture and nutrient by means of feeding through an artificially developed root

system, rather than forcing moisture through the cut end of the stalk in an effort to balance evaporation from the leaves.

With the cut end immersed in a nitrite solution\* a system of roots was grown about two feet from the lower end of a stalk in the following manner:

After cutting from the stool, a rubber boot (section of an old inner tube from an automobile tire) was slipped over the cut end. The lower end of the boot was then securely fastened to the stalk about a foot from its lower extremity. A liquid-tight joint between boot and stalk was obtained by binding the lower boot end with friction tape. The free end of the stalk below the boot was then immersed in the nitrite solution. The boot was then filled with tap water containing a few c.c.s of the dilute nutrient solution which is commonly employed in growth culture experiments. The upper end of the boot was closed so as to exclude light. In about three to four days roots began to appear at the nodes nearest the top of the boot. Instead of extending downward into the confined liquid the roots grew upward, the extremities terminating in free air. This tendency was reversed by bubbling a slow and continuous stream of oxygen through the solution in the boot. (Atmospheric air would have been employed instead of oxygen, but no method was available at the location of the experiments to permit its use.)

A photograph of one of the stalks is shown in Fig. 1. The roots illustrated are four days old, having first appeared after the fifth day of treatment. The boot is shown rolled down near the base of the stalk, the latter still immersed in nitrite solution.

Fig. 2 is an enlargement of the same root system shown in Fig. 1.

After about the fifteenth to the twentieth day of root growth, transpiration of moisture from the nitrite solution, through the cut end of the stalk, usually ceased entirely. The moisture requirements of the plant were then supplied through the roots from the solution in the boot. That this more natural process of transpiration and nutrient supply is an improvement was indicated by the renewed vigor and growth which invariably followed this treatment. The stalk was next removed from the nitrite solution, the boot was stripped off and the cane was again planted in the soil at the desired location.

The period required to produce a new root system on a cut stalk, ample for moisture and nutrient requirements, averaged about twenty days.

We have found that cane will flourish for an indefinite period after the new root system appears, regardless of whether the stalk is replanted in the soil or whether the experiment is continued with the roots immersed in the dilute nutrient solution.

Figs. 3 and 4 are photographs of the same specimen, shown in Figs. 1 and 2, after having been replanted in the soil for thirty-three days.

In lieu of using nutrient solution around a portion of the stalk, we have found that moist black sand will answer the same purpose. This latter method is to be

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\* Nitrite solution: 70 grams sodium nitrite were dissolved in 1 liter of tap water and 25 grams of conc. sulphuric acid were added. Ten c.c. of this solution were diluted to 1 liter with tap water and constitutes the "nitrite" solution mentioned in this paper.

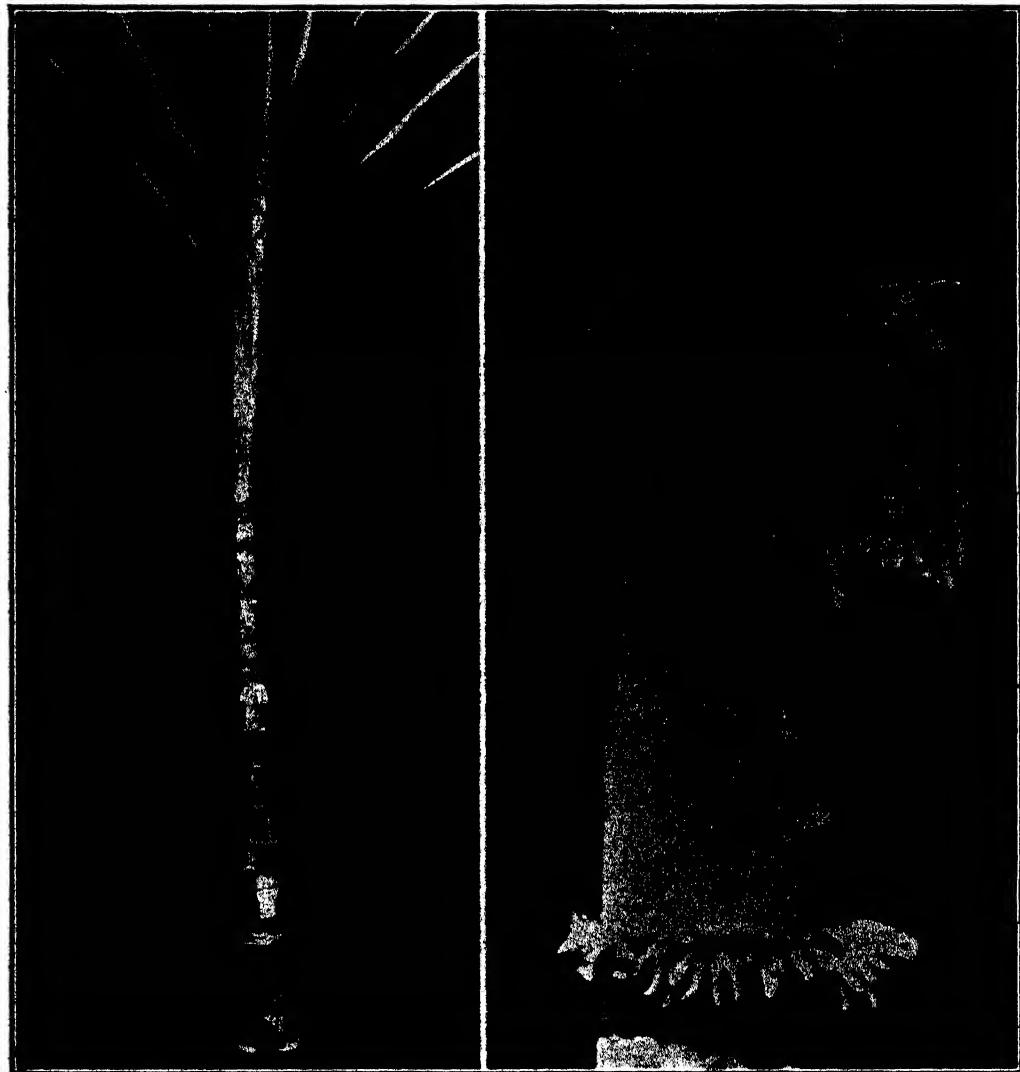


Fig. 1

Fig. 2

Fig. 1. Roots grown on H 109 cane which has been detached from the stool. The cut end of the stalk was covered with a "nitrite" solution until the twentieth day of the experiment. Roots appeared on the fifth day and were photographed four days later. The rubber boot shown above the jar was emptied of its contents and rolled down from the roots for photographing.

Fig. 2. An enlargement of the root section visible in Fig. 1.

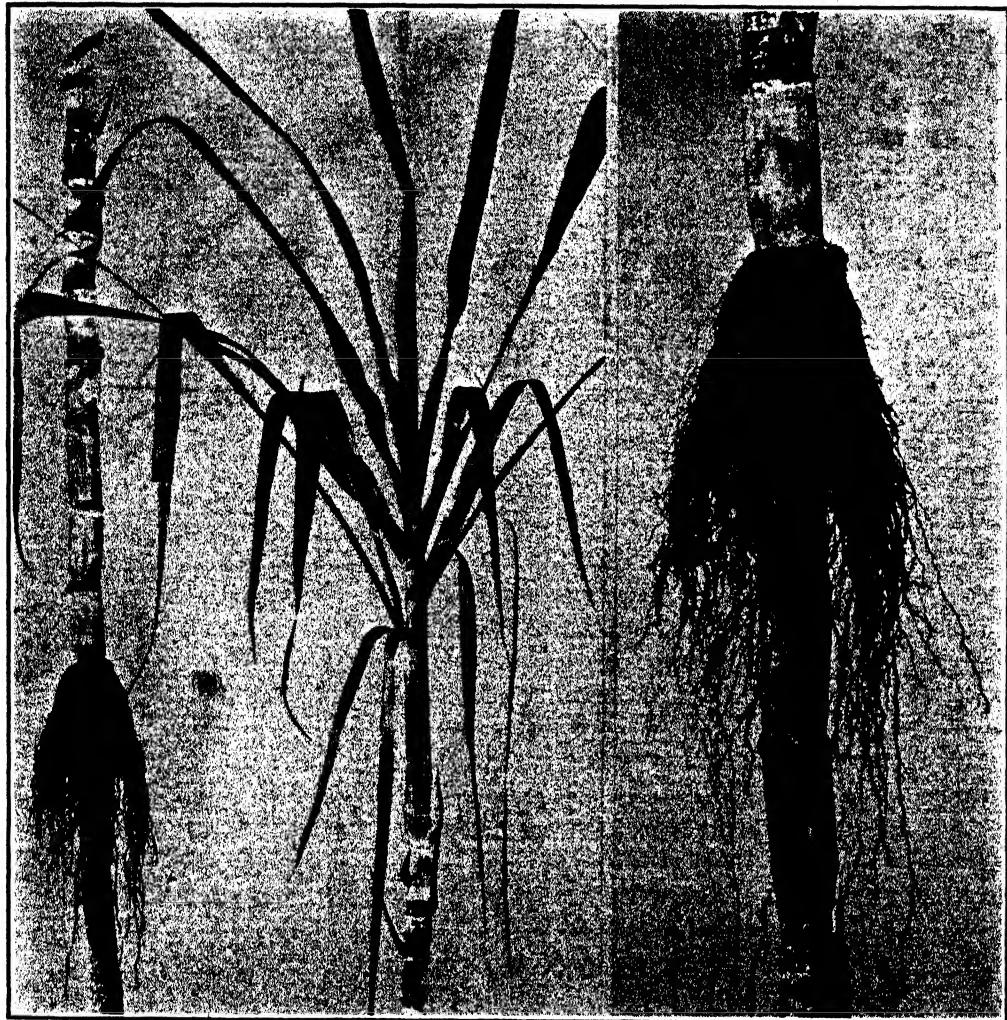


Fig. 3

Fig. 4

Fig. 3. Showing development of the same specimen thirty-three days after re-planting in the soil.

Fig. 4. Enlargement of root system shown in Fig. 3.

preferred, since the granular character of the sand permits free circulation of air and obviates the necessity of artificial air supply for the growing roots. The only attention these modified experiments required was the occasional addition of tap water to the sand in the boot. A data sheet of the history of the cut plant shown in the illustration is included as "Data of Specimen No. 606."

#### SUMMARY

This paper deals with an attempt to maintain growing conditions in a cane shoot following its detachment from the parent stool.

Preservation by movement of various solutions upward through the cut end of the stalk is discussed.

A simple method of maintaining life and securing renewed growth after detachment is outlined.

#### DATA OF SPECIMEN NO. 606

Duration of Experiment in Days	Remarks
0	Stalk cut from stool and cut end immersed in nitrite solution.
11	Boot containing dilute nutrient solution placed around middle section of bare stalk.
16	Roots appeared at uppermost nodes covered by boot. Continuous supply of oxygen started bubbling through nutrient solution.
21	Boot emptied and rolled down. Entire specimen photographed (Figs. 1 and 2).
33	Nitrite solution removed from cut end of stalk because movement of solution to the plant ceased through this agency. Moisture requirements of plant now being supplied entirely from the newly developed root system.
40	Boot removed. Specimen planted in soil.
73	Specimen removed from soil.
74	Experiment concluded. Specimen photographed. Figs. 3 and 4.

TABLE

## Immersion Media in the Preservation of Cane

Solution Employed	Remarks	Result	Period of Cane Life
.03% sulphurous acid	Employed previously by Das. Still remains the best available medium in its class.	Satisfactory in most cases	40 to 50 days
Nitrite solution (.05% nitrous acid)	A close second to sulphurous acid. Duration of growth commonly exceeds 4 to 5 weeks, with greener leaves than sulphurous acid treatment produces.	Satisfactory in most cases	30 to 45 days
Dilute nutrient solution	Rapid transpiration through cut end introduces toxic amounts of nutrients.	Failure	10 to 12 days
Tap water	Bacterial action on cut end closes vascular bundles.	Failure	1 to 3 days
Calcium sulphite and tap water	Intended to liberate a slow and continuous supply of sulphurous acid by reaction of plant acids with calcium sulphite.	Not entirely satisfactory	10 to 12 days
Tap water plus trace copper carbonate	Action of metallic salt was intended to keep down bacterial growth and thus permit tap water to pass unhindered up through the stalk.	Not entirely satisfactory	10 to 12 days
Tap water plus metallic copper spiral	The minute solubility of metallic copper in water exposed to air is sufficient to prevent growth of algae in water reservoirs and in fish aquariums.	Partly satisfactory	6 to 8 days
Tap water containing 2½ to 10% of a saturated solution of gum camphor	Anti-bacterial action desired.	Failure	3 to 4 days
Tap water containing 25% of a saturated solution of salol	Salol is used in medicine as an intestinal antiseptic. The dilute solution employed in this case did inhibit bacterial growth but its effect on the cane was toxic.	Failure	2 to 3 days
Tap water containing 1% of a saturated solution of white arsenic	Another successful attempt to prevent bacterial growth but with disastrous effect on the cane.	Failure	3 to 4 days
Sand saturated with various combinations of the solutions already enumerated	The plan of these experiments was to secure the effect of the various preservatives in the absence of light.	Failures in every case	2 to 10 days
107 combinations of the various solutions listed in this table	Mechanical and chemical devices of various kinds were used to maintain an hydrostatic head of solution at the immersed end of the stalk.	Partly successful in some cases but no results are worthy of description	2 to 50 days

## The Composition of the Pineapple Plant at Various Stages of Growth\*

By G. R. STEWART, E. C. THOMAS AND JOHN HORNER.

In considering the problem of fertilizing many agricultural crops it has been found desirable to determine the amounts of soil nutrients absorbed during the growth of the individual crop. Such data can not be used as an exact guide to the amount of fertilizer that is to be applied. A number of crops give an increased yield with smaller amounts of one or more of the major nutrients, than the crop uses during its entire growth. The final test of any problem in fertilization is best obtained by a series of properly laid out field trials. It is, however, of interest to know not only the total quantities of the major nutrients that are used by a crop, but also the period in the growth of the plant at which these nutrients are taken up.

Numerous studies of plant composition have been made upon the major agricultural crops. Several investigations have been carried out of the nutrients taken up by the maize plant at different periods in the growth of the crop. An early study of the periodic absorption of soil nutrients by this crop was conducted by Schweitzer (5) in Missouri, and a more comprehensive study was made later by Jones and Huston (3) at the Indiana Station. Willfarth, Römer and Wimmer (6) determined the composition of barley, wheat and potatoes at various periods in the growth of these crops. Burd (2) made a careful study of the rate of absorption of plant nutrients at short intervals in the growth of the barley crop in California.

Schweitzer noted that there was a rapid absorption of nitrogen at an early stage in the growth of the maize plant. Jones and Huston found a steady increase in the amount of nitrogen contained in the entire maize plant, up to the time when the plant was sufficiently mature to cut for silage. From this time on there was no further gain in nitrogen. They found also an early absorption of potash commencing just before the heads of grain had formed. This period of absorption of potash ended shortly before the plant was mature and was succeeded by a definite loss of potash in the final stage of growth. This final loss of potash was believed to be due to the leaching action of rain upon the potash salts in the leaves as observed previously by Le Clerc and Breazeale (4).

Willfarth, Römer and Wimmer found a rapid, early absorption of nitrogen and potash in barley and wheat plants, followed by a period of some loss of these constituents. They did not find an appreciable variation in the rate of extraction of nutrients from the soil by potatoes and no evidence of a final loss. Burd found a rapid absorption of nitrogen and potash by the barley plant at an early stage of growth. This was followed by a period of loss and finally by a later period of increased absorption. The conditions of the experiment precluded loss by leach-

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\* This paper covers the completion of some investigations that were unfinished at the close of a contract between the Association of Hawaiian Pineapple Canners and the H. S. P. A.

ing. It was therefore concluded that the results pointed to a return of nitrogen and potassium either to the roots or to the soil.

We have found no record of similar experiments with the pineapple crop. The study reported here was accordingly started in February, 1922, as part of the chemical work carried on for the Association of Hawaiian Pineapple Canners. The investigation was planned to give information as to how rapidly and in what amounts the pineapple plant removes nutrients from the soil. The experiment was carried on at the Kapalama plots of the Pineapple Experiment Station. The planting and cultivation of the plants was in charge of R. E. Doty and W. A. Wendt of the agricultural department of the Pineapple Experiment Station.

#### SCHEME OF THE EXPERIMENT

Two plots were laid out in one of the sections of the Station where the soil was apparently uniform in texture and depth. Each plot was planted with pineapple crowns, as this type of planting material is more uniform in size than pineapple suckers and slips. The crowns in one plot were planted in bare soil and in the other in mulching paper. In each case the two row system of planting was used in which pairs of rows are planted  $6\frac{1}{2}$  feet apart from center to center. The two rows of each pair were spaced 22 inches apart and the individual plants were set 18 inches distant in the row on the usual staggered scheme.

Before planting, the soil in each row received an application of mixed fertilizer at the rate of 650 pounds per acre. This fertilizer had the following composition: 12 per cent total nitrogen of which  $7\frac{1}{2}$  per cent was derived from ammonium sulfate, 4 per cent from dried blood and  $\frac{1}{2}$  per cent from bone meal;  $6\frac{1}{4}$  per cent phosphate, expressed as  $P_2O_5$ , derived from fine ground steamed bone meal; 3 per cent potash expressed as  $K_2O$  derived from sulfate of potash.

This preliminary fertilization was followed by a top fertilization of dried blood in April, 1923, and a side dressing of ammonium sulphate at the rate of 350 pounds per acre in June, 1923. This completed the fertilization prior to fruiting. After the plants fruited in December to January, 1924, the ratoon crop received a fertilization of 750 pounds per acre of the same mixed fertilizer that was applied before the plots were planted. The following table summarizes the applications to the plant and ratoon crops:

#### FERTILIZATION OF THE PLANT CROP

Date of Application	Amount of Fertilizer per Acre	Plant Food Applied per Acre		
		Nitrogen (lbs.)	Phosphate $P_2O_5$ (lbs.)	Potash $K_2O$ (lbs.)
Feb. 10, 1922.....	Mixed fertilizer—650 lbs.....	78.00	42.25	19.50
April 1, 1923.....	Dried blood—250 pounds.....	33.75	.....	.....
June 1, 1923.....	Ammonium sulphate—350 lbs.....	71.75	.....	.....
	Total for plant crop.....	183.50	42.25	19.50

#### FERTILIZATION OF THE RATOON CROP

March, 1924 .....	Mixed fertilizer—750 lbs.....	90.00	48.75	22.5
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Six of the crowns were taken for analysis from the selected material before planting. At three-month intervals after this, six uniform plants were harvested from both the paper and no paper plots. The plants were weighed and then washed or wiped rapidly to remove adhering soil. The pineapple plant has a distinctly glaucous smooth surface so it is not believed that the solvent action of the water introduced as great a factor of error as would have been introduced had the adhering silt been included in the analytical sample.

After cleaning and weighing the plants they were separated into the leaves and the stems and the weight of each was determined. A representative sample of each was then cut into small portions and dried at 80 to 85° C. The dried sample was ground and a composite sample of leaves and stems was made up. The percentage of nitrogen, lime, phosphate, potash and sulphur was determined in these composite samples of leaves and stems. From this data the composition of the original plants was computed. In addition, the percentage of ash, nitrogen and sulphur was determined in all the individual samples of leaves in order to give some basis for estimating the variability of the constituents in the individual plants. Composite samples of the ash of the leaves of the pineapple plants harvested at each stage of growth were subjected to a more complete analysis. This consisted of the additional determinations of silica, magnesia, sodium, iron, alumina, manganese, sulphate, chlorides and carbonates.

The plants fruited at the age of 21 to 23 months. Our harvesting of plants at 15 months of age included three plants from the paper plot which had begun to form fruit and two from the bare soil plots which were fruiting. At 18 months of age, 5 out of 6 plants from each plot were forming fruit. This corresponded very closely with the determined percentage of plants which finally fruited. On both plots 80 to 85 per cent of the plants fruited in the plant crop. In the harvesting of the plants at 21 months of age 3 out of 6 plants on each plot had partly ripe fruit. A portion of the fruit had already ripened and been removed.

Owing to the fact that we had removed part of the plants from each plot by our periodic harvesting, it was impossible for us to determine the yield of the plant crop upon the actual plots used for our study. The adjoining plots of Smooth Cayenne, which had received the same fertilization, gave a yield of 18 tons of fruit per acre on the plant crop. This yield was obtained under mulching paper. In our experimental plots the same per cent of the plants on the paper and no paper plots fruited. The fruits from the no paper plot were appreciably smaller in size. This difference in size was sufficient to make the crop from the no paper plots amount to 16 tons per acre.

After the plant crop had been harvested the ratoons were fertilized with mixed fertilizer at the rate of 750 pounds per acre. This application was made at the time the plants were approximately 26 months of age. We harvested plants at 27 months of age, and 3 months later at 30 months of age. Up to this time the growth of the plants had been entirely normal, though the ratoons were not making so vigorous a growth as the plant crop had done. After this harvesting the ratoons deteriorated rapidly and in the early fall there were indications of wilt

in both plots. The plants did not fail entirely, but it was decided that their growth was no longer normal. The harvesting of the plants was therefore not continued beyond 30 months of age.

#### GROWTH OF THE PINEAPPLE PLANTS

The growth of the plants is shown by the weights obtained at each harvesting period. These data are given in Table I and are presented also graphically in Fig. 1. In Table I, the weight of the individual crowns and plants is given for each period of harvesting. The mean weight is shown, also, together with the probable error of the mean computed by Bessel's formula. This probable error of the mean is the variation from the mean, plus or minus, within which half of the results will fall. A consideration of this figure together with the weights of the individual plants will enable one to make an estimate of the variability in growth which occurred in our plots. At most of the sampling periods the weights of the individual plants showed a moderately close agreement, but after 12 months of age there were occasional plants which varied widely in size from the group in which they were collected. We shall see later, however, that a variation in size is not accompanied by a corresponding variation in certain of the major constituents which we have determined individually. We therefore do not believe that the variability of the plants in size introduces a large error in our final calculation of the abstraction of nutrients by the crop.

The graphic representation of the mean weight of the plants at each period shows clearly that the plants raised on the paper plots were larger at each period of sampling up to the maturing of the fruit at 21 to 23 months of age. After this time the ratoons are more similar in size. We shall not attempt to draw any close deductions from this fact, owing to the partial failure of the ratoons at a later stage of development. The weight of the plants reported in Table I does not include the roots, nor fruit, when any was harvested. The roots were excluded, as we did not find it feasible to clean them of adhering soil by any method other than prolonged soaking in water, which caused appreciable alteration of the root tissues. The number of fruit harvested by us at any period was too small to form an accurate basis for a graphic representation of the development of the fruit. We shall only attempt to give an approximate estimate later of the extraction of nutrients during the growth of the fruit, with an accurate figure for the final amount taken up by the fruit harvested on the plant crop.

In Table II, we have recorded the mean weight of leaves and stems for the plants harvested from each plot at the various sampling periods.

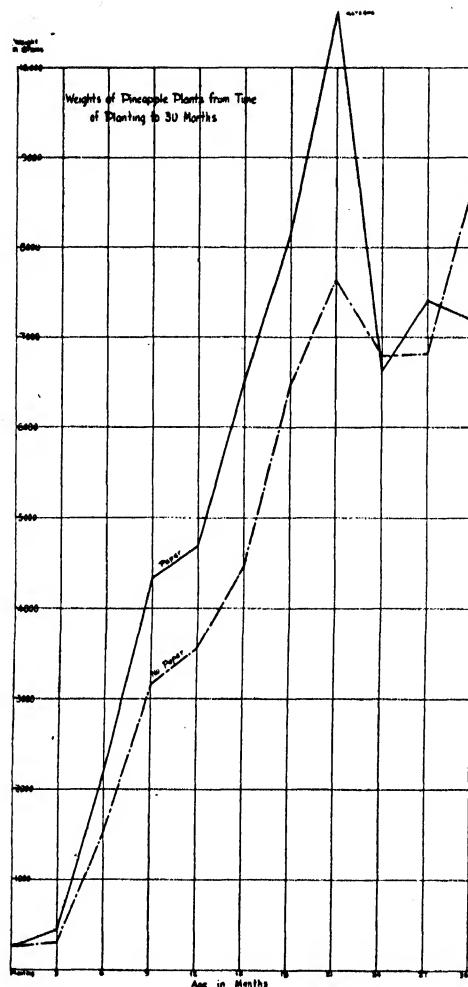


Fig. 1. Comparative growth of pineapple plants from time of planting to thirty months, with and without paper.

TABLE I

## Weight of Pineapple Plants from Planting to Thirty Months of Age

Age	No Paper		Paper		
	Grams	Pounds	Average Grams	Grams	Pounds
Crown .....	244	0.5			
Crown .....	269	0.6			
Crown .....	215	0.5			
Crown .....	287	0.6			
Crown .....	243	0.5			
Crown .....	210	0.5			
Mean Weight .....	245 ± 7.3	0.5			
3 Months .....	330	0.7	395		0.9
3 Months .....	307	0.7	507		1.1
3 Months .....	250	0.5	476		1.0
3 Months .....	280	0.6	419		0.9
3 Months .....	269	0.6	437		1.0
3 Months .....	393	0.9	455		1.0
Mean Weight .....	305 ± 13.9	0.7	449 ± 7.4		1.0
6 Months .....	1656	3.6	2174		4.8
6 Months .....	1245	2.7	2105		4.6
6 Months .....	1493	3.3	2384		5.2
6 Months .....	1583	3.5	2193		4.8
6 Months .....	1555	3.4	2109		4.6
6 Months .....	1617	3.6	2113		4.6
Mean Weight .....	1525 ± 40.3	3.4	2180 ± 85.2		4.8
9 Months .....	2529	5.6	4177		9.2
9 Months .....	3568	7.9	3352		7.4
9 Months .....	2825	6.2	4920		10.8
9 Months .....	3426	7.5	4642		10.2
9 Months .....	2966	6.5	4428		9.8
9 Months .....	3652	8.0	4363		9.6
Mean Weight .....	3160 ± 127.0	7.0	4314 ± 147.0		9.5
12 Months .....	3339	7.4	4368		9.6
12 Months .....	4174	9.2	4300		9.5
12 Months .....	3914	8.6	3650		8.0
12 Months .....	2562	5.6	5082		11.2
12 Months .....	2939	6.5	5020		11.1
12 Months .....	4373	9.6	5674		10.5
Mean Weight .....	3550 ± 198.0	7.8	4683 ± 196.0		10.3
15 Months .....	4195	9.2	6907		15.2
15 Months .....	4154	9.1	7405		16.3
15 Months .....	4806	10.6	5408		11.9
15 Months .....	4080	9.0	6220		13.7
15 Months .....	4750	10.5	6832		15.1
15 Months .....	4732	10.4	6304		13.9
Mean Weight .....	4453 ± 94.0	9.8	6513 ± 75.0		14.3

18 Months .....	6265	13.8	8645	19.0
18 Months .....	7075	15.6	7100	15.6
18 Months .....	7665	16.9	6757	14.9
18 Months .....	6640	14.6	7690	16.9
18 Months .....	5671	12.5	10270	22.6
18 Months .....	5650	12.4	8445	18.6
Mean Weight .....	6494 $\pm 221.0$	14.3	8151 $\pm 462.0$	17.9
21 Months .....	6922	15.3	9552	21.0
21 Months .....	6226	13.7	13908	30.7
21 Months .....	5719	12.6	12965	28.6
21 Months .....	6016	13.3	11977	26.4
21 Months .....	9407	20.7	5757	12.7
21 Months .....	11504	25.4	9860	21.7
Mean Weight .....	7632 $\pm 639.0$	16.8	10670 $\pm 805.0$	23.5
24 Months .....	7607	16.8	5508	12.1
24 Months .....	8012	17.7	6499	14.3
24 Months .....	4500	9.9	7593	16.7
24 Months .....	7260	16.0	7740	17.1
24 Months .....	6054	13.3	6752	14.9
24 Months .....	7342	16.2	5659	12.5
Mean Weight .....	6795 $\pm 360.0$	15.0	6625 $\pm 258.0$	14.6
27 Months .....	6173	13.6	6947	15.3
27 Months .....	7634	16.8	6488	14.3
27 Months .....	6573	14.5	5765	12.7
27 Months .....	8070	17.8	7916	17.4
27 Months .....	5990	13.2	11241	24.8
27 Months .....	6538	14.4	6081	13.4
Mean Weight .....	6829 $\pm 231.0$	15.0	7406 $\pm 557.0$	16.3
30 Months .....	6209	13.7	8655	19.1
30 Months .....	8119	17.9	7833	17.3
30 Months .....	10755	23.7	4626	10.2
30 Months .....	7091	15.6	8534	18.8
30 Months .....	9706	21.4	7929	17.5
30 Months .....	10220	22.5	5546	12.2
Mean Weight .....	8683 $\pm 505.0$	19.1	7187 $\pm 464.0$	15.8

TABLE II

Relation Between Weights of Leaves and Stem of Plant from Time of Planting to Thirty Months—Weights Expressed in Grams

Age	No Paper Plot		Total Weight	Per cent Leaves	Per cent Stem
	Weight of Leaves	Weight of Stem			
3 Months .....	264	41	305	86.56	13.44
6 Months .....	1381	144	1525	90.56	9.44
9 Months .....	2775	385	3160	87.81	12.19
12 Months .....	3085	465	3550	86.90	13.10
15 Months .....	3629	824	4453	81.50	18.50
18 Months .....	5302	1192	6494	81.64	18.36
21 Months .....	5991	1640	7631	78.51	21.49
24 Months .....	4870	1925	6795	71.67	28.33
27 Months .....	5078	1751	6829	74.36	25.64
30 Months .....	6314	2369	8683	72.72	27.28

## Paper Plot

3 Months .....	396	53	449	88.20	11.80
6 Months .....	1981	199	2180	90.87	9.13
9 Months .....	3747	567	4314	86.86	13.14
12 Months .....	4048	635	4683	86.44	13.56
15 Months .....	5154	1359	6513	79.13	20.87
18 Months .....	6727	1424	8151	82.53	17.47
21 Months .....	8284	2386	10670	77.64	22.36
24 Months .....	4886	1739	6625	73.75	26.25
27 Months .....	5324	2082	7406	71.89	28.11
30 Months .....	5062	2125	7187	70.43	29.57

TABLE III

Composition of Pineapple Plants from Time of Planting to Thirty Months—Major Constituents in Original Material

Age	Moisture per cent (H <sub>2</sub> O)	Ash per cent	Nitrogen per cent (N)	Sulphur per cent (S)	Potash per cent (K <sub>2</sub> O)	Phosphate per cent (P <sub>2</sub> O <sub>5</sub> )	Lime per cent (CaO)
Crowns before plant- ing.....	86.35	0.92	0.162	0.024	0.300	0.034	0.105

## No Paper Plot

3 Months .....	89.24	1.57	0.226	0.033	0.620	0.038	0.135
6 Months .....	89.24	1.67	0.236	0.034	0.721	0.067	0.130
9 Months .....	86.08	1.82	0.278	0.053	0.824	0.065	0.134
12 Months .....	88.16	1.53	0.221	0.048	0.658	0.062	0.114
15 Months .....	86.00	1.87	0.270	0.047	0.753	0.064	0.118
18 Months .....	88.79	1.44	0.188	0.036	0.596	0.053	0.116
21 Months .....	88.01	1.45	0.182	0.042	0.588	0.063	0.127
24 Months .....	86.55	1.34	0.180	0.043	0.547	0.044	0.118
27 Months .....	84.34	1.33	0.194	0.048	0.556	0.044	0.115
30 Months .....	84.69	1.24	0.172	0.044	0.519	0.039	0.139

## Paper Plot

3 Months .....	88.66	1.50	0.247	0.036	0.521	0.038	0.119
6 Months .....	89.40	1.62	0.225	0.036	0.653	0.059	0.112
9 Months .....	86.99	1.61	0.237	0.052	0.723	0.055	0.124
12 Months .....	88.35	1.53	0.208	0.047	0.652	0.058	0.122
15 Months .....	86.09	1.88	0.223	0.035	0.731	0.055	0.115
18 Months .....	87.42	1.64	0.200	0.037	0.688	0.052	0.142
21 Months .....	88.14	1.44	0.182	0.037	0.592	0.047	0.116
24 Months .....	85.78	1.36	0.178	0.039	0.520	0.039	0.121
27 Months .....	85.80	1.23	0.163	0.036	0.522	0.036	0.112
30 Months .....	84.68	1.34	0.168	0.046	0.567	0.039	0.139

TABLE IV

**Individual Variation in Certain Major Constituents of Pineapple Leaves at Three-Month Periods up to Thirty Months of Age**

Age	Moisture per cent	No Paper Plot			Paper Plot			
		Ash per cent	Nitrogen per cent	Sulphur per cent	Moisture per cent	Ash per cent	Nitrogen per cent	Sulphur per cent
Crown .....	86.27	0.95	0.15	0.023				
Crown .....	85.32	0.85	0.16	0.019				
Crown .....	88.65	0.86	0.18	0.019				
Crown .....	85.54	0.95	0.16	0.024				
Crown .....	87.08	1.07	0.16	0.028				
Crown .....	85.24	0.86	0.17	0.029				
3 Months....	88.87	1.49	0.24	0.029	88.63	1.51	0.24	0.024
3 Months....	88.17	1.39	0.24	0.023	88.93	1.62	0.22	0.023
3 Months....	87.50	1.57	0.27	0.019	88.25	1.70	0.22	0.020
3 Months....	88.24	1.54	0.24	0.022	89.62	1.61	0.22	0.019
3 Months....	87.56	1.53	0.25	0.025	89.54	1.45	0.21	0.020
3 Months....	89.85	1.47	0.23	0.021	89.31	1.55	0.21	0.029
6 Months....	88.65	1.66	0.25	0.028	88.58	1.68	0.21	0.021
6 Months....	89.01	1.61	0.21	0.025	88.91	1.61	0.22	0.021
6 Months....	89.00	1.71	0.22	0.026	89.02	1.68	0.22	0.023
6 Months....	89.42	1.61	0.22	0.022	89.16	1.68	0.24	0.028
6 Months....	89.92	1.52	0.19	0.020	89.25	1.69	0.25	0.028
6 Months....	89.52	1.62	0.20	0.023	89.47	1.64	0.23	0.023
9 Months....	87.50	1.60	0.19	0.041	86.88	1.45	0.24	0.026
9 Months....	88.12	1.60	0.24	0.032	86.88	1.79	0.22	0.034
9 Months....	87.50	1.69	0.22	0.041	86.25	1.87	0.29	0.038
9 Months....	86.25	1.67	0.24	0.041	85.63	2.12	0.31	0.040
9 Months....	87.50	1.68	0.21	0.034	85.63	1.92	0.30	0.040
9 Months....	86.88	1.68	0.24	0.028	85.25	2.01	0.28	0.044
12 Months....	89.40	1.48	0.16	0.030	88.70	1.39	0.20	0.027
12 Months....	89.30	1.56	0.19	0.034	88.50	1.50	0.18	0.037
12 Months....	88.50	1.58	0.22	0.031	88.60	1.56	0.22	0.032
12 Months....	88.50	1.53	0.18	0.034	88.30	1.55	0.20	0.037
12 Months....	89.60	1.38	0.17	0.032	88.50	1.57	0.21	0.033
12 Months....	88.10	1.60	0.21	0.028	89.00	1.58	0.22	0.022
15 Months....	85.50	2.01	0.23	0.025	84.80	2.14	0.32	0.038
15 Months....	86.50	1.99	0.22	0.022	86.70	1.96	0.28	0.025
15 Months....	86.30	1.91	0.21	0.023	86.80	1.91	0.24	0.024
15 Months....	86.00	2.03	0.23	0.017	86.30	1.98	0.27	0.027
15 Months....	87.00	1.72	0.20	0.017	87.00	1.98	0.24	0.028
15 Months....	85.50	2.11	0.23	0.013	86.50	2.00	0.26	0.026
18 Months....	87.30	1.74	0.20	0.028	89.00	1.42	0.17	0.024
18 Months....	87.30	1.77	0.21	0.028	89.00	1.39	0.17	0.024
18 Months....	87.50	1.72	0.20	0.027	88.20	1.53	0.20	0.026
18 Months....	86.70	1.65	0.22	0.024	88.20	1.42	0.19	0.026
18 Months....	86.00	1.75	0.21	0.025	88.20	1.54	0.20	0.026
18 Months....	86.80	1.75	0.17	0.024	88.00	1.62	0.18	0.026

21 Months....	88.40	1.47	0.17	0.025	87.30	1.69	0.20	0.028
21 Months....	88.50	1.40	0.17	0.025	88.30	1.38	0.19	0.026
21 Months....	88.40	1.46	0.18	0.025	88.10	1.50	0.18	0.026
21 Months....	88.00	1.64	0.18	0.022	87.60	1.72	0.21	0.027
21 Months....	88.30	1.57	0.19	0.021	88.70	1.40	0.15	0.025
21 Months....	87.30	1.63	0.19	0.023	87.80	1.58	0.18	0.027
24 Months....	86.90	1.53	0.19	0.020	87.10	1.34	0.19	0.021
24 Months....	85.80	1.71	0.19	0.021	88.30	1.18	0.15	0.019
24 Months....	86.80	1.42	0.16	0.020	87.50	1.39	0.17	0.020
24 Months....	86.70	1.48	0.16	0.021	86.80	1.37	0.18	0.021
24 Months....	85.80	1.51	0.18	0.023	87.80	1.43	0.17	0.019
24 Months....	86.80	1.33	0.16	0.021	87.80	1.28	0.15	0.019
27 Months....	85.20	1.45	0.17	0.024	85.00	1.20	0.15	0.024
27 Months....	86.80	1.26	0.16	0.021	84.40	1.69	0.20	0.025
27 Months....	86.40	1.22	0.15	0.022	85.70	1.30	0.18	0.023
27 Months....	85.50	1.42	0.16	0.022	86.20	1.38	0.17	0.026
27 Months....	87.40	1.32	0.15	0.019	85.60	1.72	0.20	0.027
27 Months....	86.50	1.29	0.15	0.020	86.30	1.37	0.17	0.026
30 Months....	87.50	1.31	0.16	0.024	85.90	1.20	0.16	0.022
30 Months....	86.20	1.33	0.16	0.026	85.00	1.34	0.16	0.024
30 Months....	86.20	1.45	0.16	0.026	85.40	1.27	0.17	0.023
30 Months....	82.00	1.54	0.17	0.034	86.40	1.22	0.15	0.023
30 Months....	86.00	1.34	0.15	0.027	84.20	1.47	0.16	0.026
30 Months....	85.80	1.42	0.16	0.027	87.50	1.29	0.14	0.021

The results indicate that there was essentially the same relation between the weights of leaves and stems in the plants harvested from the two plots. In other words, the plants harvested from the paper plot were larger in both leaf and stem development, up to the time of first fruiting, than the corresponding plants grown on bare soil.

#### COMPOSITION OF THE PINEAPPLE PLANTS

The analyses of the pineapple plants were made according to the methods of the Association of Official Agricultural Chemists (1). The composition of the composite samples of the entire plants, calculated to the original material, as harvested, is given in Table III. It will be seen that the composition of the plants grown on the "no paper," and "paper" plots was essentially the same at each period of growth. There was, however, an appreciable variation in the percentages of part of the major constituents present in the pineapple plants from the earlier periods to the final samples collected. Nitrogen was present in appreciably larger percentages during the first 15 to 18 months of the plants' growth. Sulphur appears to have been present in larger percentages at about the ninth to twelfth month. Potash was present in higher percentages from the ninth to the fifteenth month than it was in the latter part of the sampling periods. Phosphates were present in larger percentages from the sixth to the twenty-first month than in the last periods sampled. Lime appeared to be present in essentially the same amounts at all periods. Besides these variations in the composition of the plants during the growing period, the original crowns had a lower content of total ash, total nitrogen, total sulphur, and total potash, than was found in the growing plants.

TABLE V

### **Composition of Ash of Pineapple Leaves from Time of Planting to Thirty Months—Calculated to Per Cent on Water Free Basis**

In Table IV is given the individual variation of the plants in moisture, ash, nitrogen and sulphur at each period of harvesting. It will be seen that there was only a small variation in the amounts of these constituents among the plants of one sampling period. These results appear to us to indicate that the individual plants from the same plot did not vary significantly from each other in the major constituents at the same period of harvesting.

It was originally planned to make more complete analyses of the ash of both the stems and leaves of the pineapple plants at each period of sampling. Owing to the press of other work this was only carried out upon the composite samples of the ash of the leaves. These data are presented in Table V. The composition of the ash of the leaves from both groups of plants is essentially the same at similar ages of the plants. At part of the periods of harvesting the plants from the paper plot showed a higher content of potash in the ash than did the plants from the no paper plots. At most of the periods of harvest there was a slightly higher content of phosphates in the ash of the leaves of the paper plot plants. Beyond these slight differences there is little consistent variation between the plants from the two plots.

The largest constituent of the ash of the leaves of the plants from both plots was potash. Next in amount was carbon dioxide in the form of carbonates, followed then by silica. The content of chlorides was unexpectedly high, while lime and magnesia were present in approximately equal quantities. There was only a moderate per cent of sodium in the ash and the amount of phosphate was comparatively small.

#### COMPOSITION OF THE FRUIT

The compositions of the fruits harvested at 1½ months, 18 months and 21 months were all determined. The fruits obtained at 15 months of age were small and immature, averaging 651 grams or 1.4 pounds on the "no paper" plot and 723 grams or 1.6 pounds on the paper plot. The green fruit collected at 18 months of age averaged 1,852 grams or 4.0 pounds on the "no paper" plot and 2,108 grams or 4.6 pounds on the paper plot. The ripe fruit collected at 21 months of age, averaged 2,658 grams or 5.9 pounds on the "no paper" plot, and 2,973 grams or 6.6 pounds on the paper plot. This figure can only be regarded as approximate on account of the comparatively small number of individual fruits which were weighed. We shall, however, use it as an estimate of the approximate development of the fruit crop at the early portion of the development of the pineapple.

We found in checking the calculations for the composition of the pineapple fruit that the moisture figures were discordant, pointing to the fact that fermentation had taken place in drying the samples. We accordingly obtained another set of fruits from adjoining plots at Kapalama, which had received the same fertilization as our plots. On these fruits all moisture determinations were made at 70° Centigrade, in a vacuum oven, upon representative portions of the entire fruit, obtained as soon as the fruits were cut open. The figures obtained on these samples showed a close agreement with each other. No green fruit was obtainable at this time in any quantity at Kapalama. We accordingly obtained a series of ripe

half ripe, and green fruit from the plots of the Pineapple Experiment Station at Wahiawa, where the fertilization had been the same as that employed on our plots. We found the analytical results obtained on the ripe fruit were in extremely close agreement with the figures we had obtained on the ripe fruit from Kapalama. The results upon the green fruit have therefore been used by us, in our calculations later on, of the amounts of plant nutrients present in the fruit at 15 and 18 months of age.

The compositions of the three sets of fruit collected from the plots at Wahiawa which had received the same fertilization as our experiment are given in Table VI. It will be seen that the green fruit was consistently higher in moisture content than the half ripe and ripe fruit. There is no large change in the percentage of any of the important nutrients in the periods of sampling included in the table. It will be seen that potash is present in notably larger amounts than any of the other plant nutrients. Next in amount comes nitrogen, then lime and phosphates.

#### AMOUNTS OF PLANT NUTRIENTS REMOVED BY PINEAPPLE CROPS

From our previous Table III, we have calculated the amounts of plant nutrients removed per acre by our two groups of pineapple plants. Such a calculation should be regarded as giving only an approximate figure. In order to obtain more exact data it would be necessary to sample a much larger number of plants at each harvesting period. This was not feasible so we are submitting our estimate for such value as it may have in the study of fertilizer needs of the pineapple crop.

The extraction of nitrogen, lime, phosphate, potash and sulfur is given in Table VII, for the plants exclusive of roots and fruit. These data have been computed on the basis of 7,350 plants per acre. The same data have been arranged graphically in Figs. 2 and 3. It is very evident that potash is drawn upon in the largest amounts at all periods of growth. Next in order of absorption was nitrogen, then lime, and after this, phosphate.

TABLE VIII

Weight of Pineapple Fruit per Acre and Pounds of Plant Nutrients Removed

#### No Paper Plot

Period of growth of plant and condition of fruit	Pounds of fruit per acre	Nitrogen N lbs. per acre	Lime CaO lbs. per acre	Phosphate (P <sub>2</sub> O <sub>5</sub> ) lbs. per acre	Potash K <sub>2</sub> O lbs. per acre
15 months, green fruit....	7635	6.5	3.3	1.9	15.9
18 months, green fruit....	21816	18.8	9.4	5.7	44.3
21 months, ripe fruit.....	32000	24.9	11.8	8.3	66.9

#### Paper Plot

15 months, green fruit....	8726	7.5	3.7	2.3	17.7
18 months, green fruit....	25088	21.6	10.8	6.5	21.6
21 months, ripe fruit.....	36000	27.6	13.3	9.3	75.2

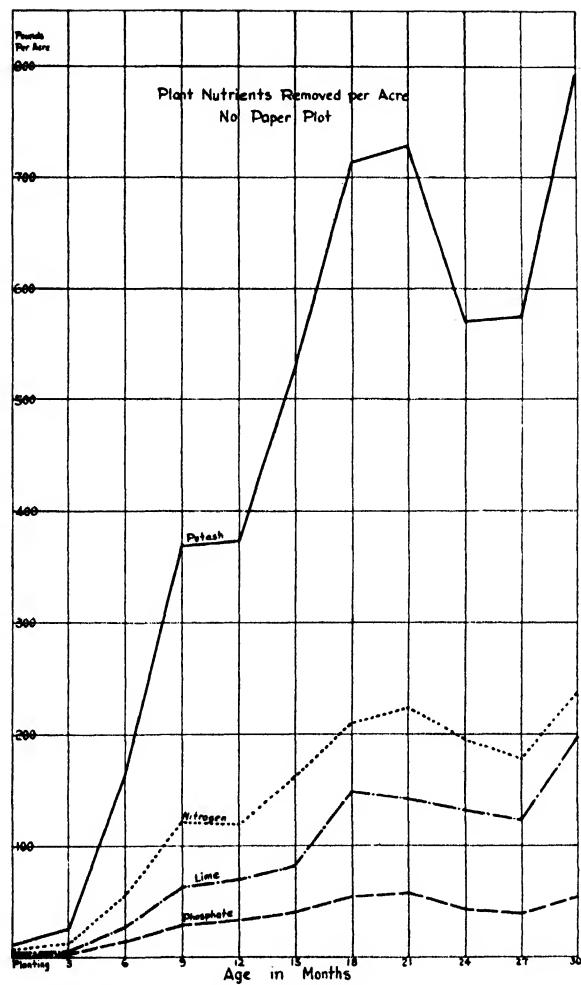


Fig. 2. Abstraction of nutrients per acre. No paper plot.

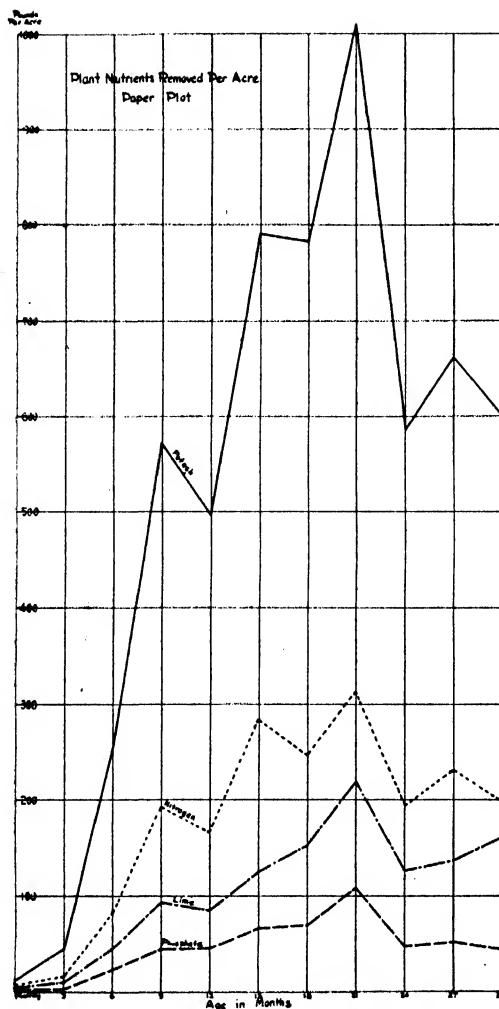


Fig. 3. Abstraction of nutrients per acre.  
Paper plot.

TABLE VI

Composition of Pineapple Fruit from Wahiawa  
Results Expressed as Per Cent in Original Fruit

No. of fruit	Condition of fruit	Moisture	Nitrogen	Ash per cent	Silica SiO <sub>2</sub>	Phosphate P <sub>2</sub> O <sub>5</sub>	Calcium CaO	Sulfate SO <sub>3</sub>	Potash K <sub>2</sub> O	Sodium Na <sub>2</sub> O	Magnesium MgO	Chloride NaCl	Carbon Dioxide CO <sub>2</sub>
1	Ripe	83.2	0.075	0.58	0.013	0.023	0.032	0.028	0.189	0.022	0.019	0.040	0.105
2	Ripe	83.8	0.080	0.52	0.015	0.026	0.037	0.017	0.235	0.022	0.017	0.029	0.129
3	Ripe	84.2	0.081	0.60	0.020	0.032	0.047	0.138	0.204	0.025	0.026	0.031	0.134
4	Ripe	83.5	0.077	0.57	0.015	0.025	0.036	0.167	0.208	0.024	0.024	0.040	0.118
5	Ripe	82.1	0.072	0.55	0.009	0.029	0.036	0.014	0.219	0.027	0.016	0.036	0.099
6	Ripe	83.3	0.086	0.68	0.013	0.025	0.036	0.014	0.204	0.022	0.024	0.036	0.125
Ripe fruit mean composition		83.3	0.078	0.58	0.014	0.026	0.037	.....	0.209	0.025	0.021	0.035	0.118
7	Half ripe	84.9	0.091	0.65	0.012	0.025	0.029	0.025	0.222	0.026	0.020	0.031	0.091
8	Half ripe	83.4	0.082	0.50	0.014	0.025	0.030	0.024	0.212	0.020	0.021	0.026	0.107
9	Half ripe	86.1	0.082	0.65	0.017	0.031	0.030	0.026	0.243	0.034	0.020	0.023	0.117
10	Half ripe	84.8	0.088	0.58	0.019	0.028	0.040	0.033	0.216	0.023	0.023	0.024	0.128
11	Half ripe	85.7	0.099	0.53	0.013	0.026	0.030	0.019	0.208	0.027	0.019	0.028	0.121
12	Half ripe	83.2	0.081	0.53	0.014	0.032	0.031	0.018	0.220	0.017	0.021	0.028	0.121
Half ripe fruit mean composition		84.7	0.087	0.57	0.015	0.028	0.031	0.024	0.220	0.024	0.021	0.026	0.114
13	Green	91.7	0.087	0.49	0.018	0.028	0.038	0.020	0.178	0.014	0.020	0.025	0.113
14	Green	89.6	0.085	0.60	0.023	0.029	0.042	0.025	0.243	0.034	0.024	0.025	0.134
15	Green	90.0	0.103	0.65	0.014	0.028	0.037	0.023	0.225	0.017	0.023	0.028	0.111
16	Green	86.9	0.069	0.56	0.016	0.022	0.038	0.034	0.204	0.027	0.022	0.026	0.116
17	Green	91.6	0.084	0.56	0.018	0.025	0.052	0.030	0.183	0.016	0.024	0.032	0.117
18	Green	88.5	0.087	0.47	0.015	0.023	0.050	0.030	0.185	0.023	0.022	0.027	0.115
Green fruit mean composition		89.7	0.086	0.55	0.017	0.026	0.043	0.027	0.203	0.022	0.022	0.027	0.118

TABLE VII

Major Plant Foods Removed per Acre by Pineapple Plants from Time of Planting to Thirty Months—Calculated in Pounds per Acre

Age	No Paper				
	Nitrogen (N)	Lime (CaO)	Phosphate (P <sub>2</sub> O <sub>5</sub> )	Potash (K <sub>2</sub> O)	Sulphur (S)
Crowns	6.4	4.1	1.3	11.8	0.9
3 Months	12.1	5.8	1.9	25.7	1.8
6 Months	55.2	27.7	14.4	160.3	8.8
9 Months	120.8	63.1	28.0	368.5	26.4
12 Months	119.2	70.1	33.0	372.8	26.7
15 Months	161.9	83.6	40.1	529.3	25.0
18 Months	209.3	148.8	54.2	713.6	38.7
21 Months	224.0	142.2	57.6	728.2	45.7
24 Months	194.9	132.1	43.1	569.9	43.2
27 Months	178.9	122.9	39.6	574.7	39.7
30 Months	234.9	195.5	54.2	793.3	64.8
Paper					
3 Months	16.3	9.8	2.7	44.9	2.4
6 Months	83.1	45.7	23.7	253.2	12.0
9 Months	193.2	93.4	45.4	573.4	36.8
12 Months	166.4	85.9	46.6	496.4	36.2
15 Months	283.4	124.1	66.9	790.9	49.3
18 Months	247.3	152.7	69.5	782.9	48.0
21 Months	313.5	219.0	108.9	1010.5	72.7
24 Months	192.7	125.5	47.5	584.5	45.7
27 Months	231.6	137.7	52.7	663.4	57.0
30 Months	199.0	161.4	44.7	601.1	51.0

The maximum absorption of nutrients took place at the time the plants fruited, at approximately 21 months of age. It should be remembered that the individual pineapple plant still continues to grow to form the ratoon plant. After fruiting the top of the former plant dies back, but a series of shoots come out at the base of the plant to furnish new fruiting material. Part of these shoots are ordinarily removed for planting stock and two of the strongest shoots are left to bear the ratoon fruits. Our plants sampled at 24 months of age were just at the period of the old top dying back, while at 27 and 30 months of age the ratoon plant was beginning to develop more vigorously. Owing to the later partial growth failure which occurred in our plots, the results obtained by us can be considered to be reliable, only, through the period of fruiting and maturing the plant crop.

In Table VIII we give an estimate of the removal of plant nutrients by the development of pineapple fruit at three periods of growth, 15, 18 and 21 months. The amounts of nutrients taken up by the fruit are small when they are compared with those abstracted from the soil by the pineapple plant. The relative absorption of the major nutrients, however, was in the same order as that which was shown for the plant in Table VII. In other words, the heaviest demand was upon the potash, which was taken up to more than twice the extent that nitrogen, the next largest constituent, was drawn upon.

## DEDUCTIONS FROM THE ANALYSES

It will be seen by consulting the schedule of fertilization that the nitrogen and phosphate applied to the crop in our experiment approach the amounts used by the pineapple plants up to the time of fruiting. The great discrepancy between fertilization and plant consumption is in the large amount of potash taken up by the crop and the small amount applied in the fertilizer. Since the time we carried out this work the applications of mixed fertilizer to pineapple crops have steadily increased. We are informed by H. L. Denison, agriculturist of the Pineapple Experiment Station, that the present fertilization will ordinarily consist of applying from 500 to 750 pounds of mixed fertilizer before planting. This is followed by a like application, later in the first season. One or more applications of mixed fertilizer are put on during the second season so that 1,500 to 2,500 pounds of fertilizer are put in prior to the time of fruiting.

After the plant crop matures, one or two applications of mixed fertilizer, ranging from 500 to 800 pounds per acre, are made to the ratoons. The amounts used will vary greatly with the appearance of the ratoons and the yield which is anticipated. The composition of the mixed fertilizer will vary appreciably, but a common formula calls for 7½ per cent of phosphates as  $P_2O_5$ , 11 to 12 per cent nitrogen, and 5 to 6 per cent of potash as  $K_2O$ . It will be seen that this heavier schedule of fertilization supplies from 112 to 187 pounds of  $P_2O_5$  to the plant crop. This is accompanied by 180 to 300 pounds of nitrogen and 75 to 125 pounds of potash as  $K_2O$ .

This heavier fertilization is producing notably larger plants and heavier yields of fruit. Our results suggest, however, that the amount of nitrogen and phosphate, now applied, probably approaches the requirements of the crop for these two constituents. The amount of potash is still far below the extraction of this nutrient in plant and fruit. It should be remembered, however, that only the fruit is necessarily sold and received from the fields. The amount of potash removed in the fruit is comparatively small. It is in fact probably no more than is at present supplied in the mixed fertilizer. Our results suggest strongly that economy of fertilization and a desire for a permanent system of soil fertility should lead every grower to attempt to return the stumps and leaves of the ratoons to the soil after the growth of the plants is completed. Such a policy may require a special study of cultural practices, but the large quantity of plant nutrients contained in the stubble warrants effort and experimentation as to the best method of utilizing this valuable material. If such a course is not followed and the stubble and stumps are hauled away to be thrown in gulches or upon waste land, it is very clear that a notable potash shortage will eventually occur in many of the pineapple fields.

## SUMMARY

- (1) The growth and composition of pineapple plants grown with and without mulching paper was determined at three-month intervals from the time of planting to thirty months of age.

(2) The plant crop grown under mulching paper was consistently larger than that grown on bare soil. The fruits produced were also larger in size. After fruiting the differences between the two sets of plants were less evident. Some growth failure later occurred in the ratoons so we shall base our deductions, largely, on the figures obtained on the plant crop.

(3) The composition of the pineapple plants grown on the paper and no paper plots was essentially the same at each period of sampling. Potash was the plant nutrient present in largest amount at all periods of growth. The percentage of potash was higher from the ninth to the fifteenth month than it was in the latter part of the sampling periods. Nitrogen was next to potash in the per cent present. It was found in largest amounts in the plants during the first fifteen to eighteen months of the plant's growth. Total sulphur was found present in largest amounts from the ninth to the fifteenth month. Phosphates were present in largest amounts from the sixth to the twenty-first month. Lime appeared to be present in essentially the same amounts at all periods.

(4) Potash was the largest plant nutrient present in the pineapple fruit. Next in order of magnitude was nitrogen, then lime and phosphate.

(5) The maximum absorption of plant nutrients by the pineapple crop was found to occur at the time of fruiting. Only a small portion of the nutrients taken up are present in the fruit.

(6) It is believed that the present systems of fertilization which supply increased amounts of nutrients, probably furnish sufficient quantities of the principal plant foods to supplement the natural fertility of the soil with the exception of potash. It is pointed out that only a small amount of the potash taken up by the plant is removed in the fruit. If the stubble is returned to the land when the ratoons are through fruiting, a heavy drain on soil potash may be avoided. If such a course is not followed, our results would indicate the probability of a future shortage of potash in pineapple soils.

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## Sugar Prices

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**96° Centrifugals for the Period  
June 17, 1927, to September 15, 1927**

Date	Per Pound	Per Ton	Remarks
June 17, 1927.....	4.55¢	\$91.00	Cubas, 4.52, 4.58.
" 22.....	4.58	91.60	Porto Ricos.
" 29.....	4.52	90.40	Cubas.
July 8.....	4.58	91.60	Philippines.
" 11.....	4.61	92.20	Cubas.
" 12.....	4.58	91.60	Cubas.
" 13.....	4.535	90.70	Cubas, 4.55; Porto Ricos, 4.52.
" 19.....	4.52	90.40	Porto Ricos.
" 22.....	4.49	89.80	Philippines, 4.52; Cubas, 4.46.
" 26.....	4.46	89.20	Cubas.
" 28.....	4.505	90.10	Porto Ricos, 4.49; Cubas, 4.52.
Aug. 2.....	4.46	89.20	Cubas.
" 3.....	4.40	88.00	Porto Ricos.
" 5.....	4.46	89.20	Cubas.
" 8.....	4.445	88.90	Cubas, 4.46; Porto Ricos, 4.43.
" 10.....	4.46	89.20	St. Croix, 4.43; Porto Ricos, 4.49.
" 11.....	4.465	89.30	Philippines, 4.46; Cubas, 4.47.
" 12.....	4.46	89.20	St. Croix.
" 15.....	4.47	89.40	Cubas.
" 16.....	4.46	89.20	Cubas.
" 18.....	4.475	89.50	Philippines, 4.46, 4.49.
" 19.....	4.49	89.80	Philippines.
" 23.....	4.505	90.10	Philippines, 4.49; Cubas, 4.52.
" 24.....	4.58	91.60	Cubas.
" 25.....	4.6133	92.27	Philippines, 4.58; Cubas, 4.61, 4.65.
" 26.....	4.65	93.00	St. Croix.
" 31.....	4.71	94.20	Cubas.
Sept. 1.....	4.77	95.40	Porto Ricos.
" 7.....	4.80	96.00	Cubas, 4.77, 4.83; Philippines, 4.80.
" 8.....	4.83	96.60	Cubas. %
" 9.....	4.77	95.40	Cubas.
" 15.....	4.87	97.40	Cubas.

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